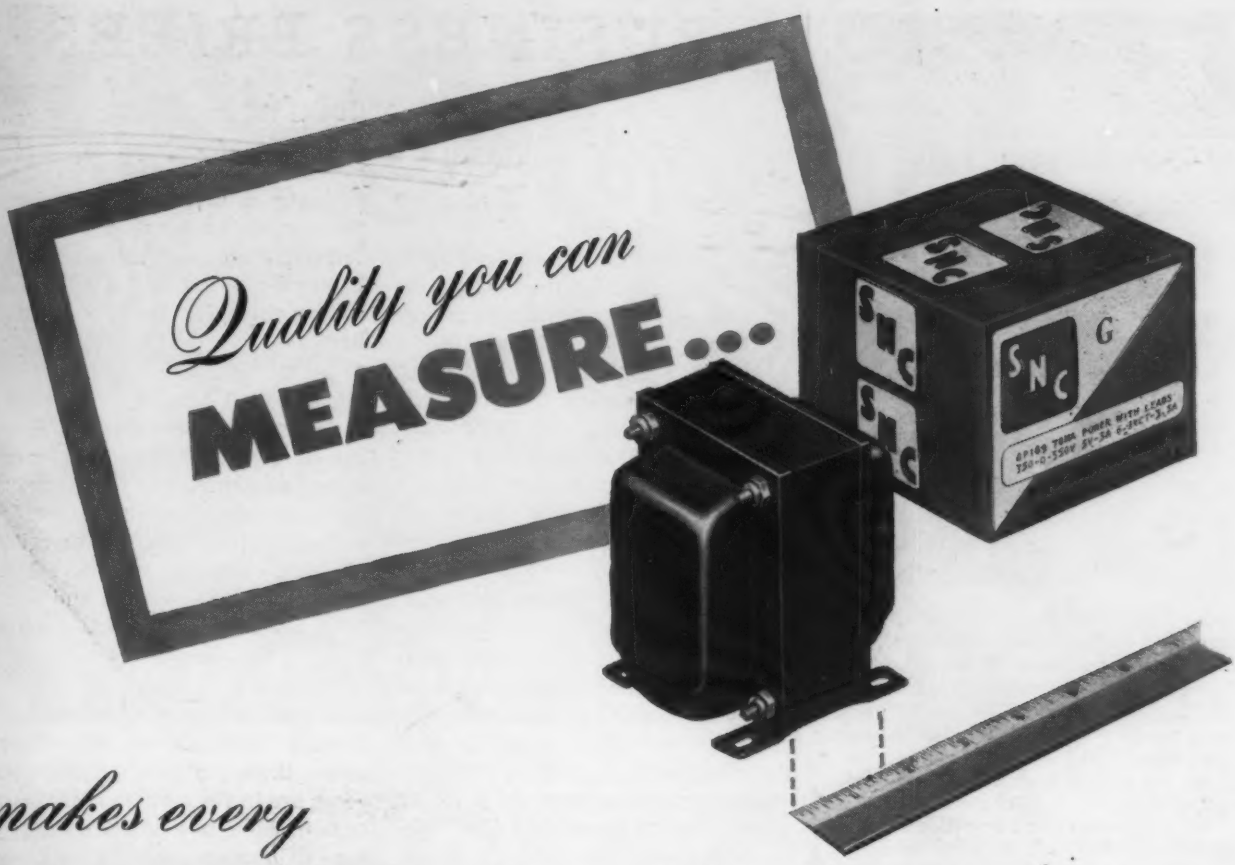

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Place a rule against the stack of an SNC No. 8P189 transformer and the *extra* width clearly indicates the added quality built into every item in the complete SNC line.

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The Solar System
electronics edition • October 1947

HIGH CAPACITANCE ELECTROLYTICS FOR LOW VOLTAGE USES

Solar Type DZTP electrolytic capacitors are widely used in low voltage applications where circuit requirements dictate extremely high capacitances. Typical applications include exciter lamp supplies in motion picture sound equipment, "A" battery power supplies, telephone and timing circuits, and electric fence machines.

All capacitors are supplied with screw terminals on a molded Bakelite top. The hermetically sealed drawn aluminum containers are furnished with an external Kraftboard insulating jacket.

Preferred ratings are as follows:

Catalog Number	Mf	Size†
12 WVDC		
DZTP-1000-12	1000	1⅜x2½
DZTP-1500-12	1500	1⅜x2½
DZTP-2000-12	2000	1⅜x3¼
DZTP-2500-12	2500	1⅜x3¼
DZTP-3000-12	3000	1⅜x3¼
DZTP-4000-12	4000	1⅜x4⅛
15 WVDC		
DZTP-500-15	500	1⅜x2½
DZTP-1000-15	1000	1⅜x2½
DZTP-2000-15	2000	1⅜x3¼
DZTP-3000-15	3000	1⅜x4⅛
DZTP-4000-15	4000	1⅜x4⅛
18 WVDC		
DZTP-1000-18	1000	1⅜x2½
DZTP-2000-18	2000	1⅜x3¼
DZTP-4000-18	4000	1⅜x4⅛
25 WVDC		
DZTP-500-25	500	1⅜x3¼
DZTP-1000-25	1000	1⅜x3¼
DZTP-2000-25	2000	1⅜x4½
DZTP-4000-25	4000	2 x4⅛
35 WVDC		
DZTP-1000-35	1000	1⅜x3¼
DZTP-2000-25	2000	1⅜x4½
50 WVDC		
DZTP-500-50	500	1⅜x3¼
DZTP-1000-50	1000	1⅜x4⅛
DZTP-2000-50	2000	2 x3½

†Add 1/16" to container diameter and 7/32" to length for overall dimensions over cardboard insulating tube.

For dimensions of other ratings, contact your nearest Solar representative or write to Solar Manufacturing Corporation, 1445 Hudson Blvd., North Bergen, N. J.

3394

SOLAR CAPACITORS
"Quality Above All"

BUSINESS BRIEFS

By W. W. MacDONALD

A Number Of Readers have asked us, some with thinly-veiled implications that are distressing to entertain, just what the formula for this column is. We don't always achieve it but here, at least, is our idea of an ideal item: It deals with the field of electronics, interests the writer (obviously the slick little gimmick used to keep stuff out), and indicates how somebody can make more money or at least avoid losing it.

More Jobs For Engineers result from the FCC's current liberality with respect to new broadcast station applications. If licenses are issued the need for engineers is obvious. Not so obvious is the fact that in order to protect their interests existing stations must do a lot of paper work to prove that they adequately serve the public in their primary coverage area, and that only an engineer can properly do such work.

Business Briefs readers should by now be quite aware of the fact that a lot of people (ourselves included) find it stimulating to keep in close personal touch with the progress of television in the nation's bars. United States Television, latest convert to this new sport for statisticians, says that the average number of lookers is 81, with a daily turnover of 353 and a weekly turnover of 984.

Seeing double is, of course, an occupational hazard.

All Is Not Beer And Skittles for bar television. Some pub owners have had to ban draught-brew sales during show periods to discourage the practice of coasting for hours on one thin dime. A few relying heavily upon rapid turnover of transient drinkers who buy a quick one and leave have actually taken sets out. Bars still represent the most effective promotion medium television has at the moment, nevertheless.

Incidentally, several shrewd New York and New Jersey operators are making themselves a nice piece of change by buying $400 table-type television sets, equipping them with larger c-r tubes and cabinets, and selling them for $1,000 or more to bars.

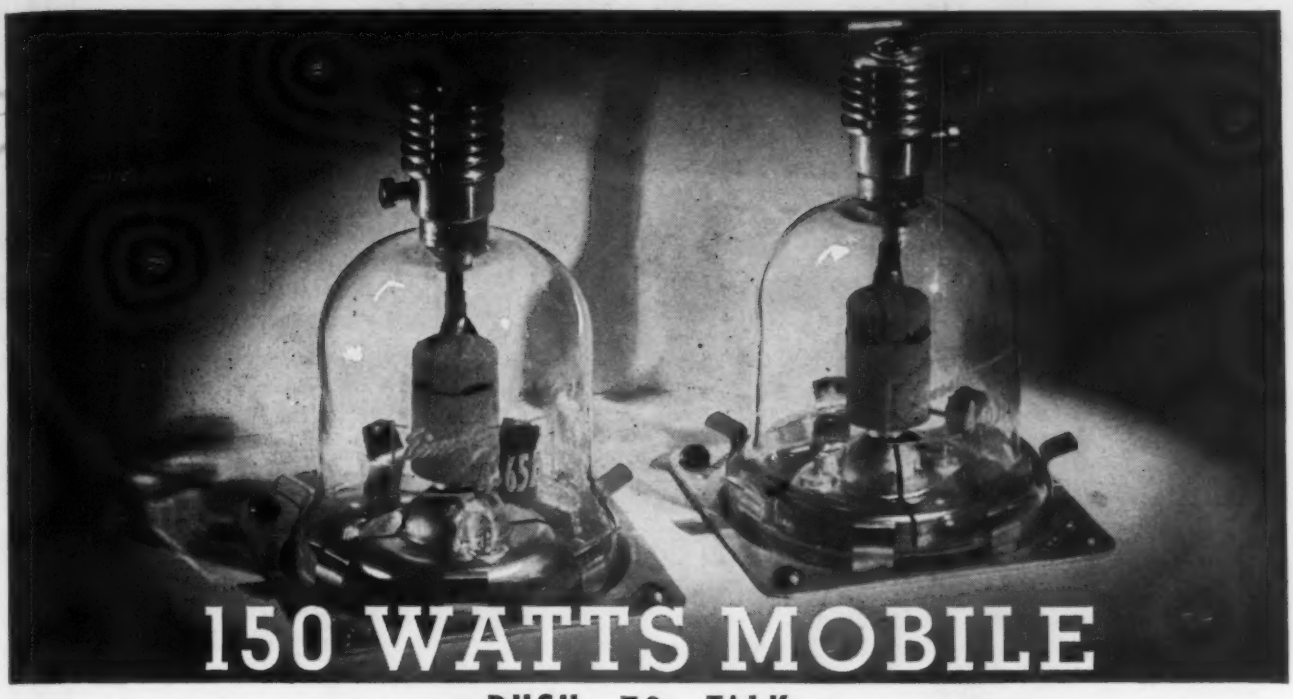
Not Yet A Law, but quite likely to be one soon because CAB is urging it, is use of electronic terrain-clearance indicators that light a light or ring a bell whenever commercial airliners get below a critical altitude. Most operators see the handwriting on the wall and are already placing orders for such devices.

Wired Wireless Schemes envisioning transmission of r-f over power lines for entertainment purposes are in for a bump if their proponents hope to avoid licensing under FCC rules permitting unlicensed operation of certain remote-control devices. A number of such schemes have been reported and the Commission is cracking down on most of them.

Surplus Electronic Equipment to be sold by the Government is just about washed up. Most of the equipment still on hand is being shifted from WAA to FWA for distribution among educational institutions. Hallelujah!

Shot In The Arm for f-m is the introduction of many new inexpensive tuners and converters now hitting the market. Stations have been screaming for them for a long time, and in many instances contracted for private-brand designs to build their market. It took nationally-known manufacturers a long time to get in production but they are rolling merchandise out now.

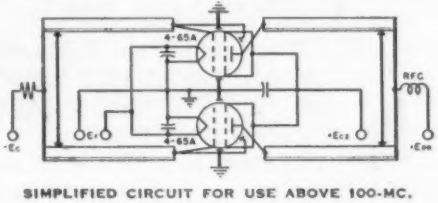
Common Carrier Service on 152 mc, for doctors, salesmen and others who must keep in close touch with their offices while driving, was predicted in these columns two months ago. Now it is an accomplished fact, with one station operating experimentally just across the



150 WATTS MOBILE

PUSH TO TALK

With the announcement of the new Eimac Tetrode type 4-65A, satisfactory high-power mobile transmission became a reality. Designed as a transmitting tube, with the transmitter man's problems in mind, the 4-65A provides stable operation over a voltage range of from 400 to 3000 volts. This characteristic alone enables continuity of system design, using the same vacuum tubes in the final stage of both the mobile and fixed station (two 4-65As will handle 150 watts input with 600 plate volts in the mobile unit, and operating at 3000 plate volts, in the fixed station, two 4-65As provide ½ kilowatt output).



SIMPLIFIED CIRCUIT FOR USE ABOVE 100-MC.

The tube is a "natural" for the 152-162 Mc. band. Its low interelectrode capacitances, compact structure, short electron transit time, high transconductance, together with being a tetrode allows simplification of circuit. Operation of the 4-65A can be continued up thru the 225-Mc. amateur band in either FM or AM service.

The 4-65A incorporates an instant heating thoriated tungsten filament, processed grids—controlling primary and secondary emission, and a processed metal plate—enabling momentary overloads without affecting tube life. All of the internal elements are self supporting without the inclusion of insulating hardware. Neutralization is normally unnecessary since practical isolation of the input and output circuits is achieved by the screen grid and its supporting cone. No special gear is required for installation, as the five pin base fits available commercial sockets.

In typical operation, class-C-telegraphy or FM-telephony, one 4-65A with a plate voltage of 600 volts, 125 milliamperes of plate current, and a plate power input of 75 watts will provide 50 watts of output with less than 2 watts of grid drive. In 1500 volt operation with an input of 190 watts, the output is 140 watts. With the plate voltage increased to 3000 volts and an input of 325 watts, an output of 265 watts per tube is obtained.

The 4-65A is amazingly versatile, being ideally suited for audio, television, r-f heating, and communication applications, stationary or mobile. It is priced at $14.50 each. Additional data may be had by writing to:

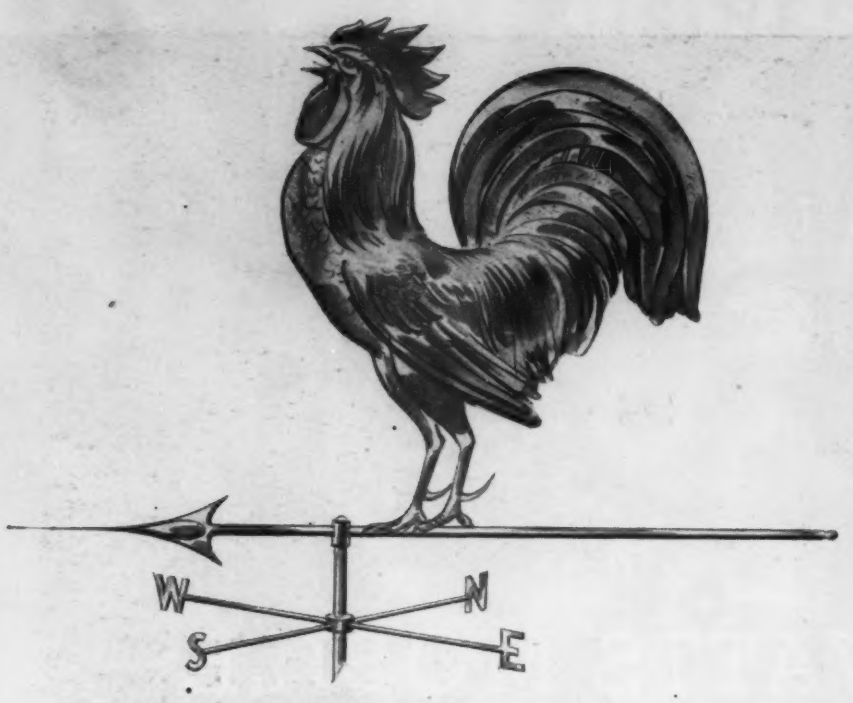
EITEL-McCULLOUGH, Inc.
181 San Mateo Ave., San Bruno, California

Follow the Leaders to

Eimac TUBES *The Power for R-F*

Export Agents: Frazar & Hansen, 301 Clay Street, San Francisco, 11, California

To insure performance of the 4-65A . . . severe mechanical tests are conducted—from withstanding a bump test to holding up under excessive vibration. Tests are carried even further . . . satisfactory shipment of the tube is insured by package drop tests.



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direction. Nor can we predict the copper market

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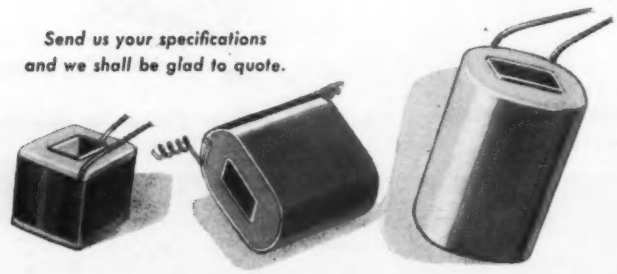
Send us your specifications and we shall be glad to quote.



COTO-COIL CO., INC.
COIL SPECIALISTS SINCE 1917
65 Pavilion Ave., Providence 5, R. I.

West Coast Address: P. O. Box 674, Belmont, Calif.

river from our New York offices, in Brooklyn, and another about to open up in Manhattan close enough to pump plenty of r-f into our typewriter.

Receiver Production by RMA members for the first six months of 1947 totalled 8,883,734 units. Here's the way the total broke down:

TYPE	PRIVATE BRAND	FACTORY
Electric		
Table (under $12.50 billing price)	97,313	484,643
Table (over $12.50 billing price)		
A-M	653,130	3,027,446
A-M/F-M	30	59,842
F-M (including converters)	.....	1,005
Consoles		
A-M	20,146	28,465
A-M/F-M	10,648	4,967
Table-Radio-Phonos		
A-M	137,206	641,105
A-M/F-M	7,311	71
Console Radio-Phonos		
A-M	74,648	431,573
A-M/F-M	33,005	328,684
Battery		
Portable A-C/D-C	119,132	921,064
Table	116,197	158,181
Consoles	284	.....
Auto	1,208,159	.....
Television		
Converters	850	24
Radio Table Models	1,015	31,754
Radio Consoles		
Direct viewing	.....	8,611
Projection	.....	618
Radio Phonos		
Direct viewing	.....	3,192
Projection	.....	325
Phonographs		
Phono only	38,650	99,493
With radio attachment	1,689	133,258
TOTAL	2,519,413	6,364,321

Receiving Tube Production for the first half of 1947 totalled 103,362,432, according to RMA. Of this total, 66,371,204 tubes went to set manufacturers, 23,920,166 were for replacement, 12,804,197 went overseas, and 266,865 were used by government agencies.

Good Management is by no means universal in the field of electronics; this we knew. But we did hope the industry would stack up better in a survey of opinion among bankers, business men, newspaper and magazine editors. Some 200 firms were nominated for a list of "best managed companies in America." Just two are in our business.

Protective Services that guard industrial plants, stores, and lush private homes against burglary and fire, and in some cases also record or control manufacturing conditions remotely, use a great deal of elec-

tronic as well as electrical equipment. Few realize that such services represent truly "big business."

One protective service company has subscribers in over 1,000 municipalities; did $14,000,000 worth of business in 1946.

Back In July we reported that a manufacturer of hotel radios had had an unhappy experience with a poorly designed quarter-in-the-slot timer. A *Business Briefs* reader (May his tribe increase!) promptly wrote in and asked if we knew of someone who might be interested in a *good* timer design he had tucked away in a closet and, if so, could we bring about a meeting of minds. We did, and we could. Which reminds us that if anyone else out there in the audience is hiding a light under a bushel we stand ready and willing to serve.

Poor Man's Pleasure is playing records, according to Admiral's Dick Graver, who says 57 percent of all phonograph owners make less than $3,000 a year.

Net Income of the Philco Corporation in the second quarter of 1947 totaled $1,626,974 after deduction of all taxes and charges including an inventory reserve of $1,200,000 for future research expenditures.

Hytron (exclusive of its Air King division) reports $43,854 net earnings after federal taxes for the first five months of the year.

Citizen's Band Radio is too good an idea to die a-borning. It needs a good push, and is going to get it. Watch coming issues of ELECTRONICS.

Story Of The Month is the one about the engineer who had designed a new gadget and asked a market-wise friend what he thought of it. Said the friend:

"A drunk once bet a bartender he could taste any mixed drink and identify it. The barkeep rattled some bottles to confuse the issue and then served a glass of plain water. The drunk sipped and thought, tasted again and admitted defeat. 'I don't know what it is,' he said, 'but I can tell you one thing . . . *it won't sell*!'"

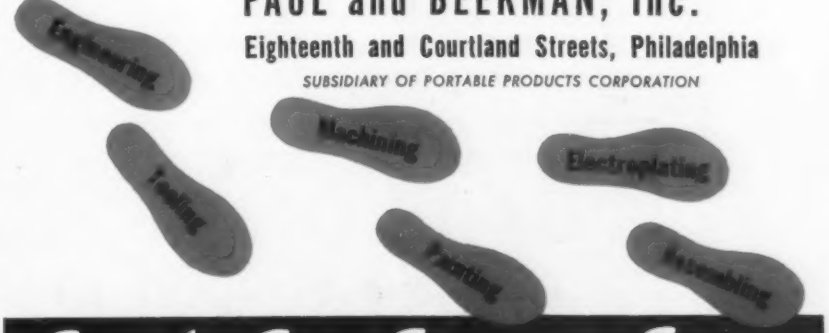
PAUL and BEEKMAN, Inc.
makes stampings in all sizes

It's one thing to be set up to make small stampings. But it's another to have the skill and the equipment to make *all* sizes of stampings, quickly and economically.

Paul and Beekman, Inc., has the skill, the men and the equipment to make precision stampings in all sizes . . . from copper, mild or stainless steel, brass or aluminum . . . assembled, painted or electroplated if required. The Paul and Beekman, Inc., service is *complete*.

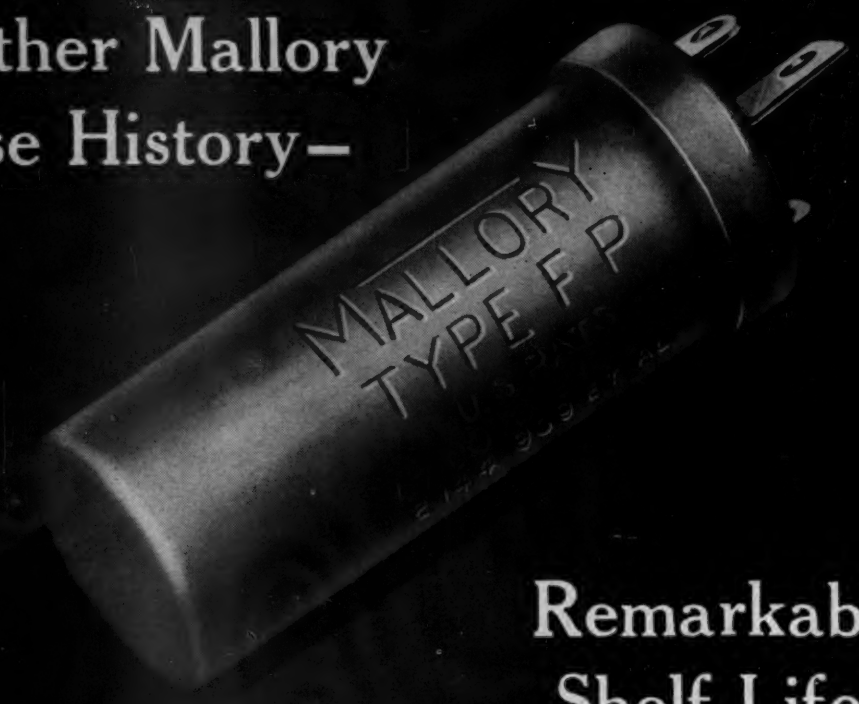
It's so *complete* that many of the best known names in industry are using it. Let us cite you some examples. Or, better still, let our engineers, without obligation to you, tell you how your specific needs would be handled.

PAUL and BEEKMAN, Inc.
Eighteenth and Courtland Streets, Philadelphia
SUBSIDIARY OF PORTABLE PRODUCTS CORPORATION



Step by Step Stamping Service

Another Mallory Case History—



Remarkable Shelf Life!

MANY YEARS AGO the Mallory FP capacitor became standard as a high quality, low cost space saver, with self contained mounting features. Now two of the first of these famous capacitors have come to light, with convincing proof of their remarkable shelf life characteristics.

Early in 1938, one of our engineers stored two of these first capacitors, without voltage, near his home, where they would be subjected to the extremes of outside weather. At the beginning of the war our engineer enlisted in the Signal Corps and forgot about his experiment. Recently he discovered the capacitors, which for *nine years* had been subjected to the heat and cold of outdoor weather conditions. They had withstood the elements with remarkable success.

The following tests were performed on the two capacitors with the results noted:

After full voltage was applied the capacitor dropped in leakage to within our specification in 8 minutes—at 30 minutes, the leakage current had dropped to .23 mills—far less than our guaranteed limit of .8 mills.

The capacitors were rated 10 mfd., 450 volts—encased in our standard ¾ x 2" FP containers. The *actual* capacity of one was found to be 10.3 mfd., the other 10.5 mfd.—series resistance of the first was 5.83 ohms, the other 4.28 ohms—the series resistance limit is 24 ohms. All of the characteristics are well within our limits.

CORROSION-FREE

One of the two units was opened for internal inspection and was found to be completely corrosion-free—the electrolyte was moist and in perfect condition. As this is written, the other is still on life test, giving excellent results.

This dramatic evidence of Mallory top quality proves again—

YOU EXPECT MORE AND GET MORE FROM MALLORY

P. R. MALLORY & CO. Inc.

MALLORY CAPACITORS

(ELECTROLYTIC, OIL and WAX)

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

CROSS TALK

▸**ATHLETE** . . . A correspondent informs us that a trespasser was apprehended some months ago at WOR's Carteret, N. J. broadcasting plant. When found he was dangling his bare feet in one of the ponds, through which cooling water is circulated, claiming it was a cure for a bad case of athlete's foot. Turns out that copper sulphate, dumped into the pond to clear it of algae and other vegetable matter, is a recognized treatment for the ailment. This story has the ring of authenticity.

Local farmers are at it again in other departments of the story-telling art. It appears: (1) Casey's creek, a small body of water near the station, gives out with the programs; (2) so do the water faucets in nearby farmhouses; (3) lights in hen coops cannot be turned off while the station is on the air, resulting in greatly increased egg production and weary hens; (4) cows grazing on grass growing on the station plot produce twice as rich milk as cows restricted to less vital pasture. Our favorite is the athlete, dangling his feet and munching idly on a spear of tall (vital) grass.

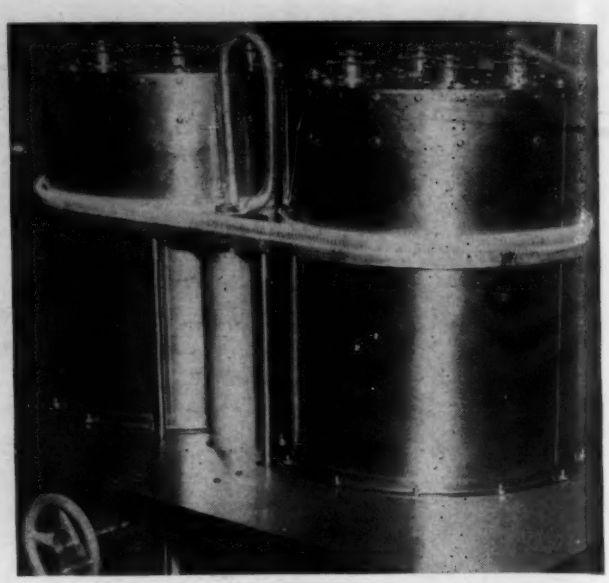
▸**LIGHT** . . . The radio business, we remind ourselves, is based on a simple technique, accelerating electrons back and forth along a wire at a sufficiently rapid rate to cause the radiation of energy. By dint of much struggle, the rate of the alternating accelerations has been pushed up to 100 billion per second, producing waves a fraction of a centimeter long.

Now comes word that this technique has been applied, by members of the G. E. Research Laboratory at Schenectady, to accelerate electrons so fast that they produce not microwaves but visible light, at frequencies in the range of 10^{14} cycles per second, or a hundred million megacycles. The technique, described recently in Electron Art (p 136, September), involves the rapid whirling of an electron beam in the 70-million volt synchrotron, accompanied by radial deceleration or acceleration in a magnetic field.

There are, of course, simpler ways of producing light, by bouncing electrons against atoms in an incandescent lamp filament, for example. But this is the first direct observation of acceleration of an electron, analagous to feeding current to an antenna, to make it produce its own light. The achievement bespeaks a new extension of our control over electrons, of no commercial value for the present, but of great scientific interest.

▸**COMPUTERS** . . . J. R. Newman, writing in a recent issue of the *New Republic* (p 14, June 23, 1947), has produced a brilliant essay on electronic computers, one of the finest examples of technical writing for the layman we have seen. Among the many acute observations made are three we think should particularly interest the engineer: First, the awful complexity of the big computers (18,000 tubes in the ENIAC) is giving way to simpler organisms of even greater power. The MANIAC, (the rumored name of von Neumann's Princeton machine, for "mechanical and numerical integrator and calculator") will do everything that ENIAC will do, but has less than 1,000 tubes. Second, the introduction of memory devices and alternate-sequence programming circuits (which automatically select a future course of computation based on a numerical result achieved during the course of solving the problem, without human intervention) has endowed the machines with rudimentary "personalities" and subjected them to psychic disturbances. They may even develop dual personalities and attempt, like any schizophrenic, to go off in two directions at once. Third, the vast saving of time afforded by electronic computation, is particularly vivid in Newman's words. The ENIAC, taking into account wind direction and velocity, air temperature, rotation of the earth and spin of a projectile, will compute the trajectory of the shell in less time than it takes the shell to reach its destination. D. R. Hartree the English physicist (who, incidentally, helped us to understand how a multicavity magnetron works), spent fifteen years of his life computing atomic structures. The job could have been done by electronic computers in hours, or days at the most.

Anode tank



Cathode tank

KSBR's 50-kw High-Band F-M Transmitter

Operating experimentally on 100.5 mc since April 23 at the maximum power permitted by the FCC, the equipment described is nearing commercial perfection. Details of the r-f section, employing unique tank circuits and a new multi-unit tube, are given

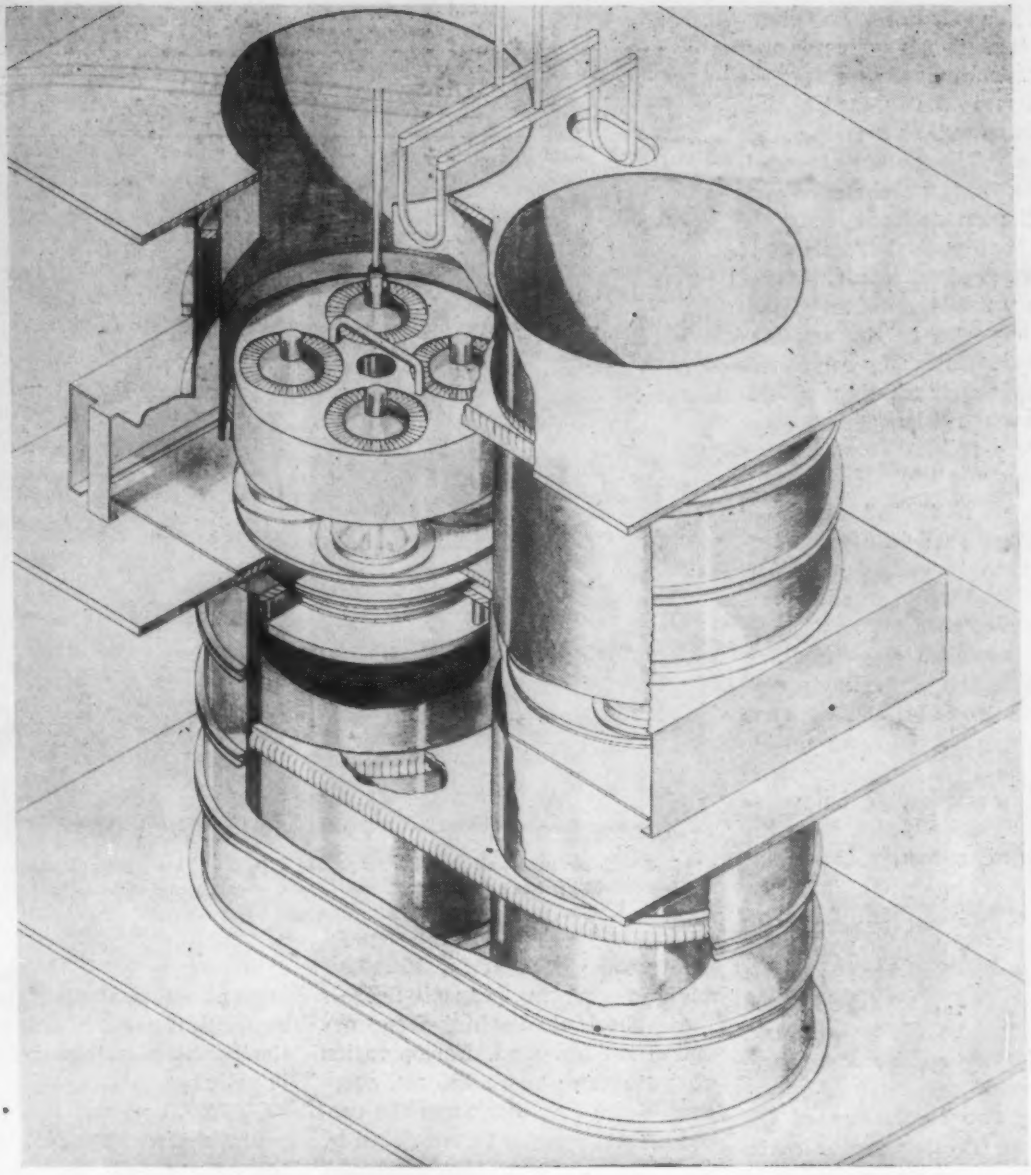
By R. L. NORTON
Application Engineering Dept.

BYRON O. BALLOU and R. H. CHAMBERLIN
Laboratory — *Engineering Dept.*

Eitel-McCullough, Inc.,
San Bruno, California

TO DEVELOP 50 kilowatts for the so-called f-m high band new tubes and new circuit techniques are necessary. This is a description of the 100.5-mc transmitter of KSBR, designed and built for Radio Diablo, Inc. by Eitel-McCullough. The transmitter has been operating experimentally since April 23 from a temporary location in the latter's laboratory at San Bruno. It will soon be installed on 3,800-ft. Mt. Diablo, overlooking the San Francisco Bay area.

Starting from a Radio Engineering Laboratories, Inc. dual-channel phase-shift modulator and frequency multiplier chain, the transmitter requires only three air-cooled stages to reach the 50-kw output level, as shown in Fig. 1. Following the modulator and frequency-multiplier unit is a 3.5-kw push-pull-parallel tetrode stage. This stage drives a push-pull, gounded-grid triode amplifier which raises the power level to 13 kw. A 50-kw grounded-grid stage follows, with either two four-unit triodes in push-pull or eight single triodes in push-pull-parallel. All stages following the modulator operate from a common power supply, at an effi-



Cutaway drawing of 50-kw final r-f amplifier stage, employing a grounded-grid circuit. Adjacent photos show anode (top) and cathode (bottom) tank arrangements

ciency (total d-c plate input to useful output to the transmission line) of 68 per cent.

3.5-kw Amplifier

The 3.5-kw stage, shown in Fig. 2, at present consists of four 4X500F's in a push-pull-parallel arrangement driven directly from the 829B output stage of the exciter unit. These tubes operate at an overall efficiency of approximately 72 percent. Neutralization is accomplished by tuning the screen grids to ground. This stage will be replaced by four 4X500A's, which do not require neutralizing at f-m broadcast frequencies.

The cooling system used in the 3.5-kw amplifier is unusual, and is similar to that used in all air-cooled stages in the transmitter. Conventional practice in air cooling tubes is to have the cooling air enter the open end of the anode cooler and leave through the base end. In a vhf transmitter using linear tank circuits this requires that air enter through the anode tank lines and exhaust into the amplifier itself. In the KSBR transmitter air enters the cooler of each air-cooled tube from the base end and exhausts

through the anode lines. The greatest advantage of this system is that incoming cool air is passed over the glass between the adjacent electrode seals as well as over the seals themselves. The principal disadvantage is that the chamber containing the anode tank must be sealed so that air leakage direct to atmosphere does not occur. In vhf apparatus this is a minor disadvantage, however, as the amplifier anode circuit is normally completely enclosed by nearly air-tight shielding to prevent r-f leakage.

13-kw Amplifier

A pair of 3X2500A3 air-cooled triodes is employed in a grounded-grid circuit as a second amplifier, shown in Fig. 3. This amplifier was originally designed to use four tubes as a so-called ring amplifier, with four-conductor cathode and anode tank circuits. These tank circuits, which are the resonant-line equivalent of a four-wire transmission line in which diagonal wires are connected in parallel, have the advantage of reducing the surge impedance to less than half the value of a two-wire line of equivalent spacing-to-diameter ratio.

Initial tests indicated that it would be feasible to develop well over the required 10 kw with two tubes, and the amplifier was therefore converted to push-pull operation, using two conductors of the original four in each tank circuit. To preserve symmetry in the cabinet, two of the conductors which had been at diagonal corners of the four-conductor tank circuit were used. The resulting tank circuits have high surge impedance and the cathode tank circuit, which has the highest shunting capacitance, is quite short at the high-frequency end of the f-m band. For operation at frequencies above 105 mc, coupling to the amplifier from the preceding stage would be simplified by the use of closer tank-conductor spacing and the resulting increase in physical line length.

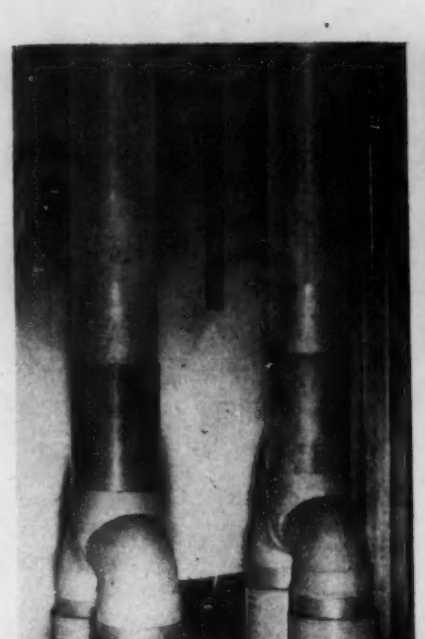


FIG. 2—3.5-kw push-pull-parallel stage of 50-kw f-m transmitter

FIG. 3—13-kw push-pull stage, anode tank at top and cathode tank at bottom

50-kw Amplifier

The 50-kw final amplifier tank circuits are illustrated in the drawing and adjacent photos appearing on the first pages of this article and the complete amplifier is pictured in Fig. 4. It uses a pair of 3X12500A3 triodes in a grounded-grid circuit. The 3X12500A3 is a new multi-unit thoriated-filament triode designed specifically for the purpose of efficiently producing an output of 25 kw per tube at f-m frequencies, but is obviously suited to a number of other applications. Figure 5 shows the tube, which consists basically of four units of the 3X2500A3 type assembled on a common mounting. Low-inductance discs interconnect the filament and grid terminals of the four units. Grid and filament contact fingers are provided on the tube, so that the socket consists simply of concentric rings against which the tube is held by suitable clamping means. The four units are assembled in their mounting in such a way that individual units may be replaced at the factory.

In any amplifier using air-cooled

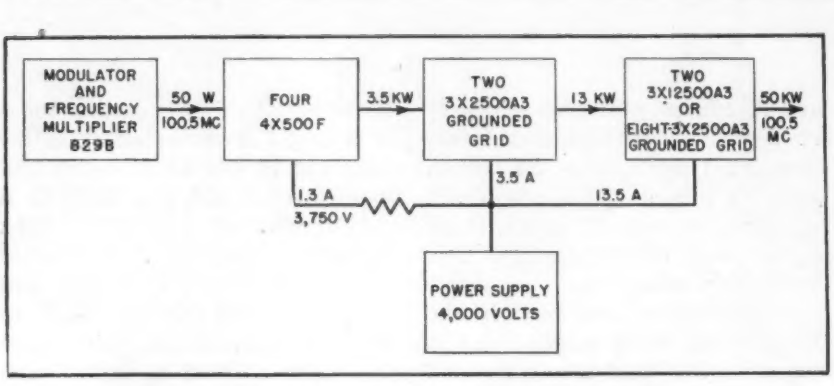


FIG. 1—Block diagram of the 50-kw f-m transmitter

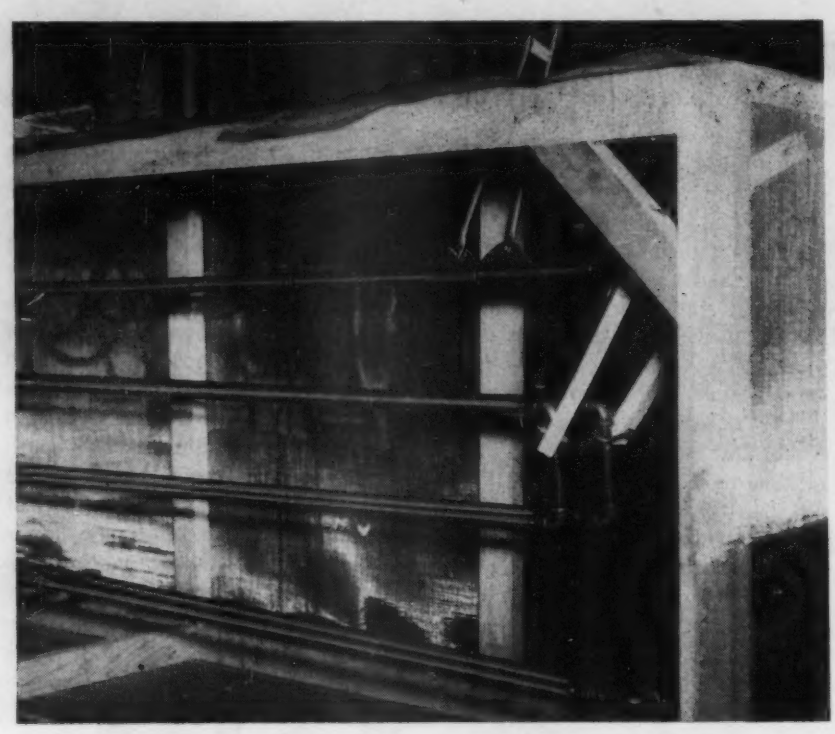


FIG. 7—Dummy load used in testing the KSBR 50-kw transmitter

ment, is located on the transmission line near the point where it connects to the coupling loops, to allow tuning out the reactance of the loops.

Operation

Typical operating conditions for the three amplifier stages are given in Table I. The amplifier delivers 50 kw at 100.5 mc with relative ease. A power output of 58 kw has been obtained without exceeding tube ratings.

The most difficult problem encountered in the design of the 50-kw stage was the coupling circuit used between the amplifier and its preceding driver stage. The rms cathode-to-cathode voltage on the amplifier is only about 1,500 volts. The power delivered to the amplifier cathode circuit is approximately 13 kw, resulting in a cathode-to-cathode impedance of approximately 180 ohms.

Originally the coupling system between the amplifier and its driver consisted of a length of three-inch 50-ohm coaxial line coupled by relatively small loops to the plate circuit of the driver and the cathode circuit of the amplifier. Two coaxial stubs spaced one-eighth wavelength apart were located on this line near the amplifier end. In order to pass sufficient current through the coupling loop at the amplifier end to couple to the low-impedance cathode circuit, it was necessary to have a high standing-wave ratio in the section between the stubs and the amplifier. This resulted in a very high voltage point one-fourth wave back from the coupling loop with consequent frequent flashovers. The present coupling system consists of a pair of $\frac{3}{8}$-inch copper tubes spaced $1\frac{1}{2}$ inches and connected to the cathode tank near the cathode end. By means of a single movable stub on this line it is possible to reduce the standing-wave ratio to a point where the losses are tolerable, and at the same time obtain sufficient coupling to the cathode tank circuit.

Output Measurements

Output measurements on the transmitter have been made by use of a calorimeter load shown in Fig. 7. This load consists of a two-wire transmission line of $\frac{1}{2}$-inch black iron pipe with 6-inch spacing. The line is 40-feet long, and is folded back on itself to make an overall length of 8 feet. Both ends of the line are shorted, and an additional adjustable shorting strap is provided at the end opposite that at which the power is applied. Cooling water enters at a tee in the lower fixed short and travels through both pipes in parallel, leaving by way of a tee at the upper short. Power is applied through a two-wire transmission line from the transmitter which is tapped onto the load near the upper short. Standing waves in the transmission line from the transmitter are eliminated by adjusting the tap point and the position of the lower movable shorting strap. Complete shielding of the load is necessary to prevent loss of power by radiation. With a water flow of approximately 5 gallons a minute, a temperature rise of 140 F is obtained in the water passing through the load. Power is calculated from the rate of flow, temperature rise and the specific heat of water.

There is some radiation of power from the transmission line between the transmitter and the load, and also some resistance loss in the transmission line. These losses have been neglected in Table I. Allowance for the losses might increase the transmitter power output figure by one or two kilowatts.

Table I—Operating Conditions in Last Three Stages

	First Amplifier (Four 4X500F)	Second Amplifier (Two 3X2500A3)	Power Amplifier (Two 3X12500A3)
D-C plate voltage	3,750	4,000	4,000
D-C plate current (amp)	1.3	3.5	13.5
D-C grid voltage	−200	−500	−500
D-C grid current (amp)	0.075	0.5	1.8
D-C screen voltage	500	.....	.....
D-C screen current (ma)	0.055	.....	.....
Driving power (approx, kw)	0.050	3.2*	12.5*
Useful power output (kw)	3.5(2)	13*	50

*Discrepancies between driving power and power output of preceding stages are due to losses in coupling circuits.

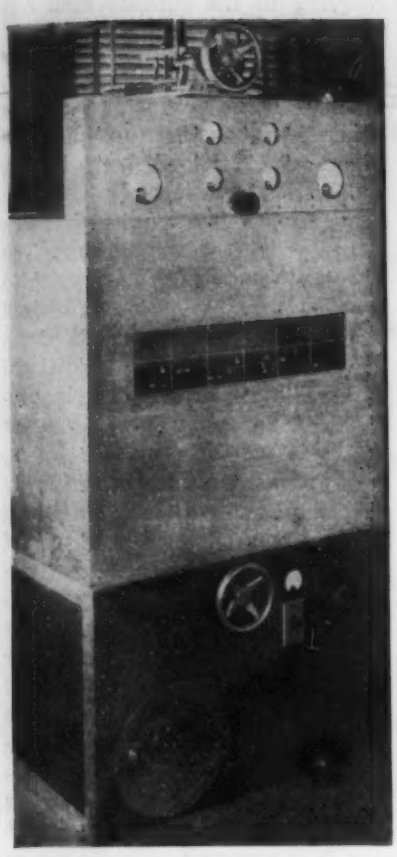


FIG. 4—The complete power amplifier designed and built for KSBR

tubes and capable of delivering 50 kw at 100.5 mc the transverse dimensions of the tank-circuit conductors themselves tend to become an appreciable portion of a quarter wavelength, and it is possible for voltage differences to exist between points on the end of a conductor which should be at the same potential. For this reason, it was deemed advisable for the initial tests on the 50-kw stage to employ separate 3X2500A3 tubes rather than grouping them together on common mounting surfaces. Separate tubes combined with separate anode blocking and grid by-pass capacitors allow individual metering of the grid and anode currents, so that the degree of loading and excitation to each tube can easily be observed. The amplifier is arranged so that it will, with minor modifications, accommodate eight type 3X2500A3's in push-pull-parallel or two 3X12500A3's in push-pull.

The cathode-to-cathode input capacitance of the amplifier is approximately 150 $\mu\mu$f, which makes it necessary to employ as a cathode tank a balanced line having a surge impedance in the neighborhood of ten ohms if the circuit is to be used on its fundamental mode. An unshielded two-conductor line of this impedance would have a spacing-to-conductor-diameter ratio of about 1.005, and would therefore require impossibly large conductors if the conductor-to-conductor spacing were any reasonable value. Most of the r-f current would flow in a small section of the conductors where they faced each other, with the result that unequal excitation voltages would be supplied to the four cathodes on the end of each conductor.

The cathode tank circuit used is shown in the drawing and an adjacent photo and consists of two 12-inch diameter conductors on 14-inch centers. These two conductors are completely enclosed by an oval shield spaced one-half inch from the conductors. The conductors and the shield are fabricated from sheet copper stock. Tuning of the cathode tank circuit is accomplished by changing the position of a shorting plate, shown in Fig. 6, which contacts the two tank conductors and the shield. The shorting plate is moved by means of four lead screws which are linked together by chain and operated from a panel control through bevel gears. At resonance the cathode tank circuit is approximately one-eighth wavelength long.

Tank Circuit Details

Dividing the amplifier into two separate sections is a $\frac{3}{8}$-inch thick 24-inch-by-36-inch duraluminum plate, which serves as an isolating shield between cathode and anode circuits. The cathode-tank shield is fastened firmly to the lower face of the shield.

The anode tank circuit is similar to the cathode tank circuit. In the anode circuit, however, the spacing between the conductors and the shield is one inch, as the anode tank does not need to be as low in surge impedance as the cathode circuit. When shunted by the output capacitance of the amplifier tubes, the anode tank circuit is slightly over one-eighth wavelength long at resonance. The shorting plate is similar to the one used in the cathode circuit, except for a larger outer dimension to accommodate the larger shield.

Power is taken from the anode circuit by means of two loops which enter from above and project through slots in the shorting plate into the field around the conductors. The two loops are connected in parallel at their upper ends, and feed an open-wire transmission line leading to the antenna. The coupling loops are supported at their upper ends by a piece of sheet Teflon, which can be driven up or down by lead screws to allow adjustment of the amount of coupling to the anode circuit. A single stub, adjustable as to length and place-

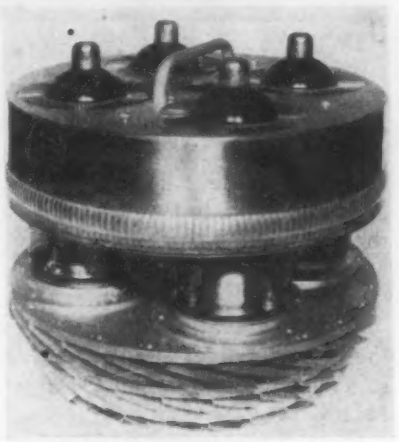


FIG. 5—Eimac 3X12500A3 multi-unit triode, two of which are used in the KSBR 50-kw f-m transmitter final r-f amplifier

FIG. 6—Movable shorting plate used to tune final r-f amplifier cathode circuit

UHF HEATING of Frozen Foods

Problems encountered in developing 1,050-mc continuous-wave magnetron oscillator equipment for thawing and heating precooked frozen food. Operating at a frequency comparable to the newly allocated 915-mc band for electronic heating, the unit makes a vegetable, potato, and meat too hot to eat in 70 seconds

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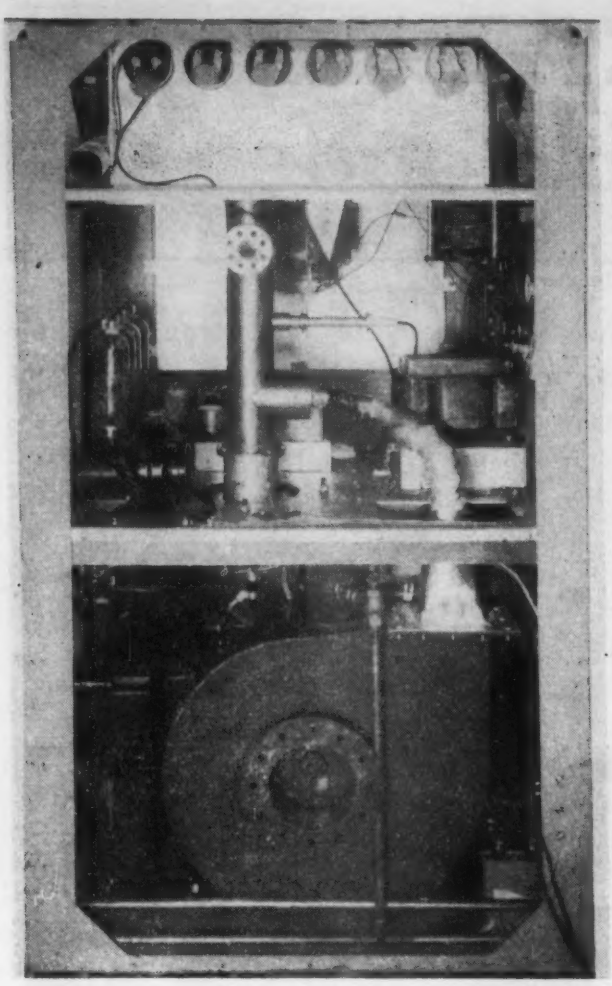
THAWING and heating precooked frozen meals electronically offers several advantages. When these meals are heated by conventional methods such as a hot-air oven, the thawing and heating time is never better than 15 minutes. This factor alone limits use, particularly in restaurants. When the heating is done in a minute the restaurant can prepare food in off-peak hours, keep its menu in deep freeze and thaw and heat dinners when they are ordered. Obviously such a food dispensing system eliminates much of the waste inherent in present-day restaurant methods of food preparation and saves the restaurant owner from the daily losses which he now suffers because he has to guess what his volume of business will be.

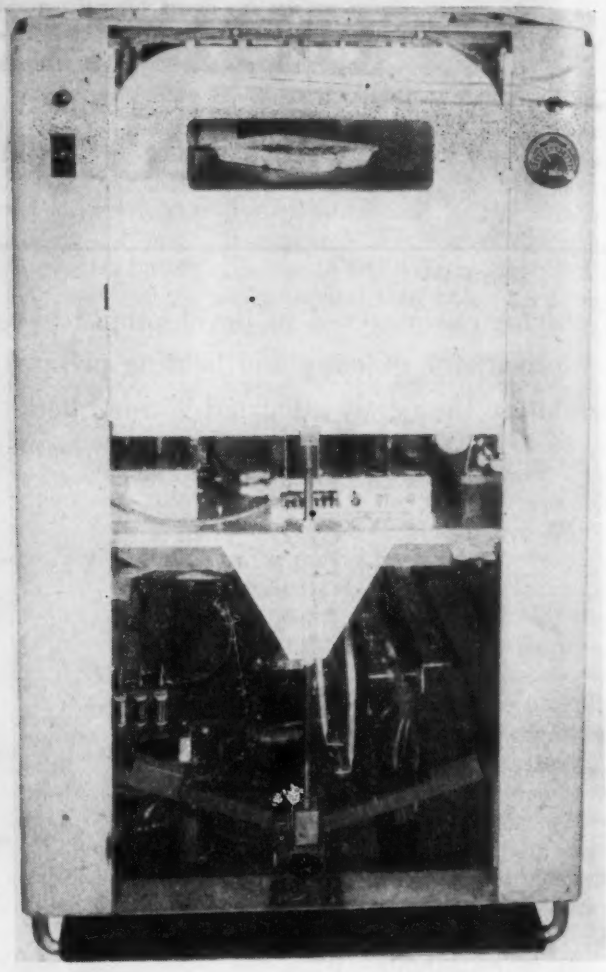
Electronic heating of food produces the heat from within. Therefore, the only thing that heats in the electronic oven is the food. Since at the frequency involved a heating unit is about 50-percent efficient, food thawing and heating by electronic means can be made capable of operation at higher efficiencies than by the conventional conduction methods.

Investigation of food thawing and heating using the ultra-high-frequency band was conducted primarily because arcing between food

Only 70 seconds are required to heat a frozen meal from zero Fahrenheit to a temperature too hot to eat



Rear view of electronic heater. Heating cavity on top shelf. Rectifier tubes at left, transmission line in center, and control circuits to right of second shelf. Air blower and power transformer occupy the bottom portion in the cabinet



Front view of heater. A slotted door provides access to the heating cavity and is operated by the foot treadle at bottom of the unit. Electronic control chassis are just visible on the second shelf. A water line is used for cooling

masses occurred at frequencies of 40 megacycles and below. This arcing started before sufficient power could be coupled into the food for useful purposes. Peas, for example, are especially vulnerable to this kind of arcing. The high voltage gradient necessary for the heating of foods at lower frequencies rendered them impractical.

It was, therefore, decided to use a frequency approximately twenty-five times that of the highest frequency used before the war to heat foods. Since heating is directly proportional to frequency times the voltage gradient squared, increasing the frequency to 1,050 megacycles lowered the voltage gradient for the same amount of heating by a factor of five. Arcing was eliminated when this procedure was followed.

From this experience it might be supposed that there is no limit to how high one can go in frequency for the heating of food. But this is not the case. Penetration difficulties are apparent as soon as a frequency of much over 1,000 megacycles is exceeded.

Equipment Used

Figure 1 shows the basic elements of the developmental setup. The three and one-eighth inch transmission line from the magnetron was equipped with a directional coupler as well as a slotted line for indicators in matching the impedance of the load to that of the line. Provisions were also made for inserting a triple stub or movable sleeve transformer for impedance matching. Various load cavities were tested under this arrangement to determine their characteristics and suitability for food heating.

Early heating of precooked frozen dinners by ultrahigh frequency was carried out in a waveguide-shaped cavity using the $H_{0,1,n}$ mode, where n was any whole number between 3 and 6. See Fig. 2. Input coupling was made with a variable probe length. The frozen

dinner plate was placed at an experimentally determined position in the cavity. It was learned that by varying the input probe length and the position of the dinner plate along the cavity, settings could be found which gave a very good impedance match (small reflections of power, see Fig. 3) in the melted or partially melted state. However, impedance match in the frozen state was not as good.

Food Data at UHF

These findings indicate that electrical characteristics of food in the frozen and unfrozen state are quite different. Table I gives the changes encountered in the electrical characteristics of various common foods at 1,000 megacycles. Note the considerable variation in a given food between the frozen and unfrozen state. Peas at 23C have a dielectric constant of 9 and loss tangent of 0.5; the same peas have a dielectric constant of 2.5 and a loss tangent of 0.2 when frozen.

When it is considered that every food in a precooked frozen dinner undergoes an electrical change comparable to the change in peas, the overall impedance change is a major problem; naturally this impedance variation is accompanied by a variable amount of power reflected back to the generator during the heating cycle.

The energy required to bring food from 0F through the melting point at 32F is about the same as the energy needed to raise the melted food from 32F to 170F. As a result, any system which heats food evenly must be able to heat both in the frozen and unfrozen state. No system which couples energy to only one state of the food will work. This poses still another problem: to devise a heating cavity insensitive enough to impedance changes during the heating cycle of the food to give a satisfactory impedance match and, at the same time, heat the food evenly at 1,050 megacycles.

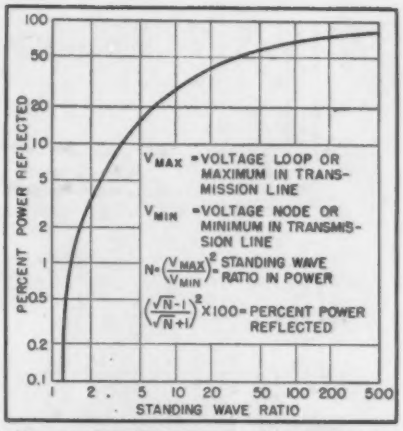


FIG. 3—Standing-wave ratio in power, plotted against percent power reflected

Since the plate is approximately eight inches in diameter, it covers the maximum and minimum heating area in the modes set up in the cavity. Consequently, at no time is uniform heating attained in cavities of this type. Different load configurations, such as tapering the load and the cavity as shown in Fig. 4, to counteract for heating differentials were tried. Various types of cavities producing relative motion between the food and field were studied. None of the methods was entirely successful in overcoming differences in heating. When the load was moved, or the field within the cavity was shifted, difficulty was experienced in coupling power due to overall impedance changes.

From the experiments in the waveguide-shaped cavity, a number of facts were learned which tended to clarify the problem. Contrary to what was generally believed before the developmental work was undertaken, heating is uneven in both horizontal and vertical planes. Further analysis of this problem, plus the fact that it was much easier to couple energy into the unfrozen food, indicated that the heating effect of frozen food is a runaway proposition. Once the food thawed at one point, that specific spot had a tendency to absorb more than its proportionate share of the energy. The configuration of the electromagnetic waves within the cavity was, in a large measure, de-

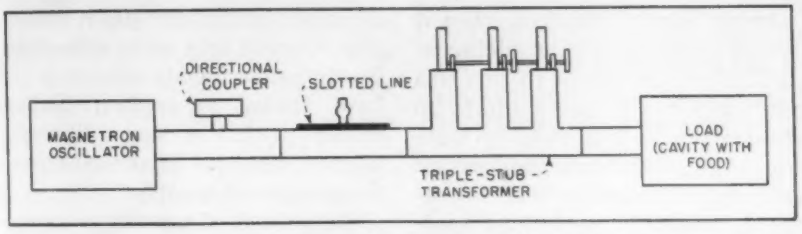


FIG. 1—Waveguide arrangement used for feeding uhf energy from the oscillator into the food

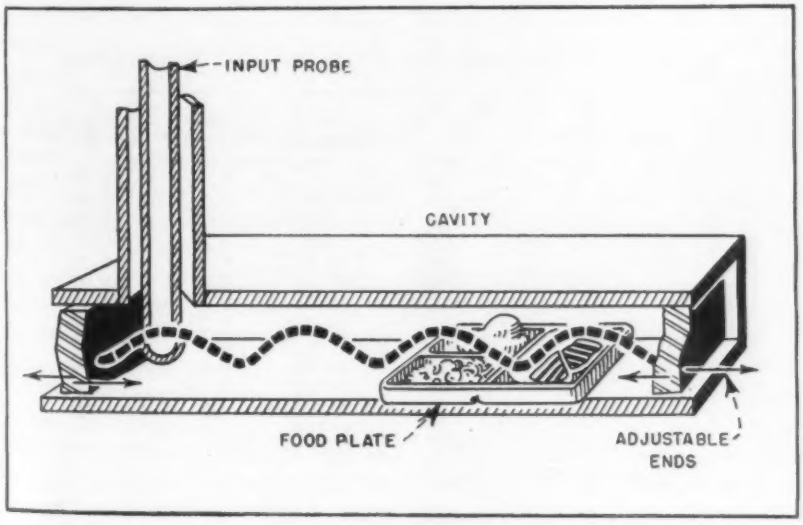


FIG. 2—Impedance matching is done by varying the probe length, the position of the food, and the length of the cavity

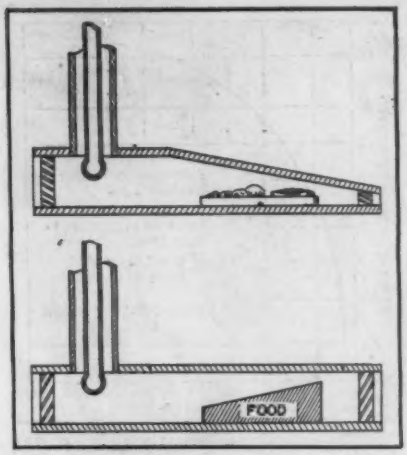


FIG. 4—Tapering the cavity and the food load, as shown above, provides more uniform heating but does not entirely solve the problem

termined by the partially melted food. This configuration was so set up in the cavity as to continue the heating in the areas already melted, because the high loss points establish the field configuration rather than vice-versa.

Inconclusive results were obtained in efforts to counteract this tendency for food to overheat at the original points of melting. In every case, considerable impedance changes were experienced, indicating that the partially melted foods were distorting the field within the cavity to the extent that external controls had little or no effect upon the overall picture.

From a frequency point of view, tests have shown that the runaway tendency in the ultrahigh frequency heating of precooked frozen meals is more troublesome when the frequency is higher. At approximately 3,000 megacycles this effect is three or four times greater.

Effect of Standing Waves

Early tests also indicated another condition of heating which was not wholly apparent when the tests were first undertaken. By measuring the standing wave in a waveguide-shaped cavity in which a very thin layer of mashed potatoes was placed, it was found that the greatest heating effect took place at the point of voltage minimum. Since this problem was originally approached from the dielectric heating standpoint, the previous notions of the type of cavity to be used were changed to some extent. Instead of dealing with high voltages, it was necessary to look at the problem from the point of view of relatively high circulating currents which were induced in the food due to its good conductivity. In other words, the impedance match of the electromagnetic energy into the potato was best at the low-voltage point in this particular cavity.

Because the ratio of the electric vector to the magnetic vector in an electromagnetic field is dimensionally an impedance, it suggests that this ratio must be the right value for correct impedance matching into the food. This also hints the interesting theory that the heating of foods at this frequency may be considered to be more analogous to ultrahigh frequency induction heating rather than dielectric.

A number of cavities were built embodying the idea of heating taking place at the voltage minimum. As a general rule, it was no problem to couple energy into food when it was placed at the voltage minimum. Under these conditions heating was very localized — any effort to broaden the heating area by moving the food through the heating zone, or shifting the field by external means, changed the impedance so much that this type of heating was considered undesirable. Since these cavities were designed to heat intensively at localized points, it was noted that some distortion of the food occurred when too much energy was pumped into it in too short a time.

One suggestion, evolved by the size of the heating areas, was to separate the food plate into its three component parts and place the plate so that each part occupied a distinct heating area in the cavity. A waveguide-shaped cavity was used and the three units of the food plate were placed at three separate voltage minima. Heating was uneven between the three separate units because the food unit which melted first continued to absorb energy at a rate greater than its proportionate share of the available power.

No Aid from Steam

Existence of steam in a food unit would tend to equalize the temperature differential during the heating cycle, it was believed. No conclusive results were obtained. By way of explanation, the heating cycle is obviously too fast for steam conduction to exert any noticeable effect. Further experiments along this line have tended to confirm that it makes little or no difference whether the food is covered during the process of heating.

Since the Q of a cavity is proportional to the ratio of energy stored to energy dissipated, it was believed that a very small cavity (minimum

Table I—Characteristics of Foods at 1,000 Megacycles

Specimen	Temp. of Test (C)	Dielectric Constant	Loss Tangent*	Penetration (inches)**
Beef, raw	−15	5.0	0.15	2.28
Beef, roasted	23	28.0	0.2	0.97
Peas, whole, boiled	−15	2.5	0.2	3.12
Peas, whole, boiled	23	9.0	0.5	0.59
Pork, raw, ground	−15	6.8	1.2	0.26
Pork, ground, 50% fried	35	23.0	2.4	0.07
Potato, boiled	−15	4.5	0.2	2.39
Potato, boiled	23	38.0	0.3	0.57
Spinach, boiled	−15	13.0	0.5	0.56
Spinach, boiled	23	34.0	0.8	0.22
Squash, baked	−15	5.0	0.3	1.46
Squash, baked	23	47.0	0.8	0.16

* Dielectric constant in complex form is $\epsilon = \epsilon' - j\epsilon''$

Loss tangent: $\tan \phi = \frac{\epsilon''}{\epsilon'}$

** Depth at which power density falls to $\frac{1}{\sqrt{e}}$ or 0.6 of the surface value. $e = 2.7183$

size for the frequency used) would have a low Q and therefore good characteristics. Many of these cavities presented excellent loading qualities, both in the frozen and unfrozen state, and could be considered satisfactory from this standpoint alone. Unfortunately, the cavities were small and the food had to be located very close to the coupling loop. Invariably, the food nearest the loop was badly burned and distorted by the high energy level at this portion of the cavity.

Changes made in the interior cavity structure, either by shielding or by spacing the loop from the food, did not entirely overcome this difficulty. It should be pointed out that a low-Q cavity similar to the type described was used with considerable success at one kilowatt of power. Provided the power level is low enough (heating cycle long) cavities operate with fair results.

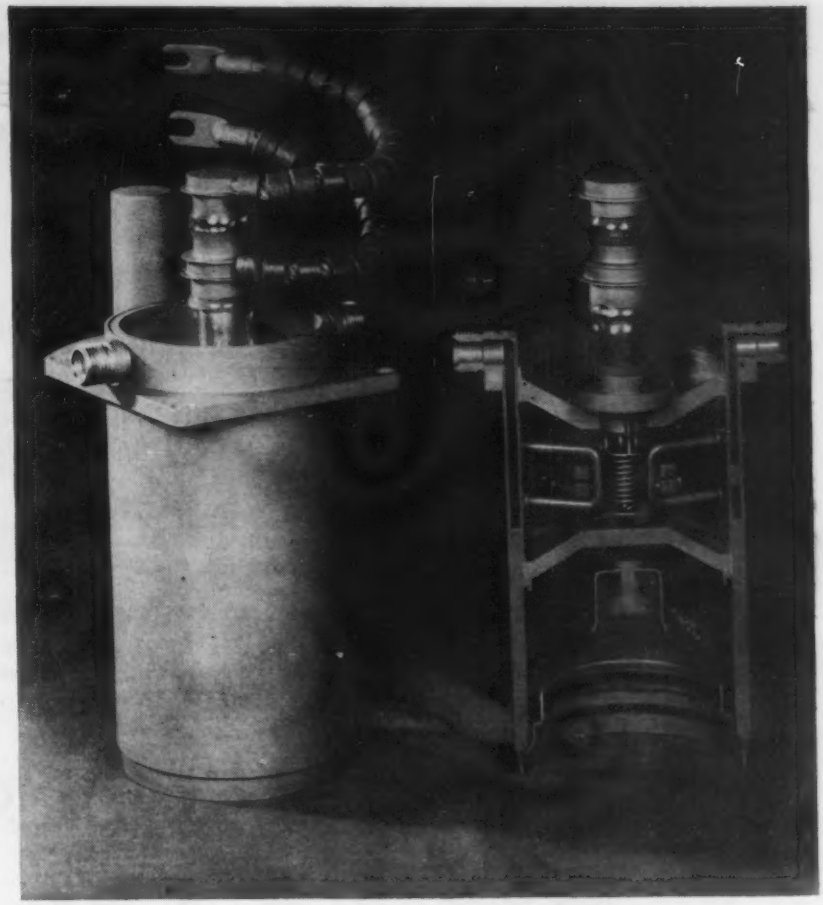
Foolproof Design Needed

Cavity designs which will operate satisfactorily for heating precooked frozen meals were only part of the overall problem. There were certain requirements to contribute to the unit's ease of operation in limited floor space. Since it must be presumed that the electronic oven will be operated by aspiring short-order cooks, the operation of such an oven must be as nearly automatic as possible. No delicate external tuning adjustments for use during the heating cycle can be tolerated and the oven must be able to handle a wide variety of meals. Undoubtedly most operators will be inclined to experiment and treat the unit as a toy, so provisions must be made so that the equipment will not be damaged with any kind of load. Finally, such an oven is limited in the floor space it must occupy because it will be used where floor area is very much at a premium.

Equipment has been developed which substantially meets the general requirements. For all intents and purposes, it is automatic in its operation. A power switch, a load timer (0-120 sec), and a foot treadle are the only controls necessary for operation. When the unit is turned on, a 40-second time delay prevents the use of the equipment until the tubes are heated. As soon as the green indicator light above the power switch lights, the oven is ready for operation. This is done by merely placing the frozen meal in the oven and stepping on the foot treadle; from then on, the operation is automatic. The cavity door slides into place, power is applied, and the meal heats as long as the load timer dictates.

When the heating cycle is over, power is cut off and the cavity door drops down. All the operator need do is remove the heated meal from the electronic oven and the machine is ready to begin a new heating cycle. While power is being applied to the food, a red indicator light above the timer shows. By pressing this indicator light any time during the heating cycle, heating can be terminated and the cavity door will drop down. The equipment is so designed that the operator is protected by the usual door interlocks and other means.

Due to the great number of vegetables and meats that comprise a meal, precooked frozen dinners present an almost infinite number of combinations. Our experience has indicated, nevertheless, that with one or two exceptions, the electronic oven will handle this wide variety of dinner combinations with satisfactory uniformity. Tests have shown that 12-ounce precooked frozen dinners, consisting of a vegetable, potato, and meat, can be heated from 0F to a temperature too hot to eat in 70 seconds. The meals were not specially prepared for use in this equipment, but were a standard commercially produced product. They were refrigerated months earlier, then reconstituted to the peak of cooking freshness in 70 seconds.



Complete magnetron and cutaway view showing internal construction. A continuous-wave type, it is capable of providing five kilowatts of output power at 1,050 megacycles

Typical installation of antenna array for vhf omnidirectional radio range. The five loop elements are in the small structure atop the 30-foot-diameter circular counterpoise, and are connected to the transmitter in the building below by means of solid-dielectric cable

Status of VHF Facilities for Aviation

THE VHF RADIO PROGRAM of the Civil Aeronautics Administration has three main parts: (A) vhf radio ranges for air navigation; (B) vhf localizers and markers for instrument landing systems at airports; (C) vhf communication between ground stations and airplanes.

The vhf ranges will ultimately replace the present network of low-frequency four-course aural ranges. The changeover from the latter type of facility is dictated by two basic factors: (1) the need to avoid or minimize the problem of natural interference such as atmospherics, which is very severe in the 200-400 kc band; (2) the need to move into a portion of the spectrum less congested than the lower band. The present network of low-frequency aids more than saturates the band, and yet is not adequate for the needs of air navigation. The importance of these two factors to the safety and dependability of air navigation is absolutely paramount.

Since the vhf facilities operate at frequencies which can be received only within line-of-sight distances, approximately, it follows that for aircraft at an altitude of 1,000 feet above the terrain the service area has a radius of the order of 35 to 40 miles. This type of facility is therefore classified as a short-distance navigation aid. The frequency channels can therefore be repeated at certain geographical intervals—in this case, 500 miles based on a maximum altitude of 18,000 feet. The frequency band available for this use (112-118 mc) permits 30 channels 200 kc wide and the geographical distribution is on this basis. When and if receiver manufacturers develop a more practical and reasonably priced receiver capable of handling 100-kc spacing and channels, the available frequencies will be, of course, effectively doubled. (Present equipment capable of 100-kc spacing is too expensive for all but large types of commercial aircraft.)

The vhf ranges provide all of the services now available with the low-frequency aids and at the same time furnish additional information and greater flexibility of use.

The instrument landing system runway localizer is also in the vhf band for the above reasons as well as for added convenience. Its function requires a radiation space pattern of such sharpness as to result in an impracticable antenna array at frequencies much below those now in use (about 110 mc). These circumstances, combined with judicious system design in such mat-

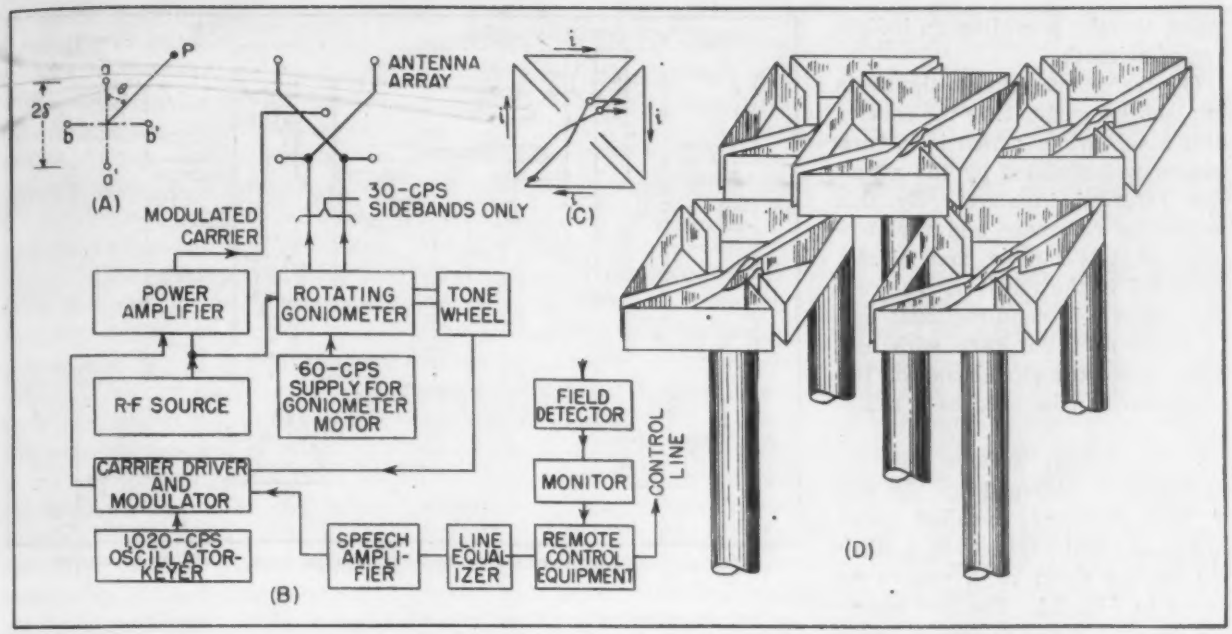


FIG. 1—Antenna array and transmitter equipment used at ground station of vhf omnidirectional range, which operates in the band from 112 to 118 mc. With distance-measuring equipment in aircraft, one station like this is sufficient for an absolute fix

Technical details of the vhf omnidirectional radio range now being installed throughout the country by CAA for short-range air navigation, along with operating principles of glide-path portion of CAA instrument landing system and new phase-comparison localizer

By PETER CAPORALE

Chief, Radio Engineering Section, Civil Aeronautics Administration, Washington, D. C.

ters as modulation, have resulted in a single airborne unit for the use of both ranges and runway localizers. The desirability of this situation is obvious.

The markers of the instrument landing system (ILS) are in the vhf band, but the glide path is not (it operates at about 335 mc). The system will be discussed below in its entirety since the particular glide path frequency is not inherent in the functional aspects of the ILS as a whole.

In the problem of ground-air-ground communication, the basic considerations are again freedom from natural interference and adequate frequency channels to provide for the expanding load created by air navigation. Therefore, the vhf communication program will also ultimately replace the m-f and h-f circuits now being used.

This program, including the specific types of facilities involved, is in accord with the conclusions reached internationally by ICAO (previously PICAO) in Montreal in November 1946.

The VHF Range

The basic radio aid for air navigation is the vhf omnidirectional range operating in the 112-118 mc band. This is a facility which provides two reciprocal tracks from the station. The azimuths of these tracks, however, are selected by the pilot so that he may use a track at any desired azimuth around the station, without any discontinuities over the entire 360 degrees. It is this fact which gave rise to the term omnidirectional. Once the pilot has selected a track, any deviation of his path from the track will result in a right or left deflection of a zero-center instrument in the aircraft. This instrument will read zero when the plane is on the track and is, in fact, the localizer portion of the cross-pointer instrument used with the vhf ILS localizer developed by CAA.[1]

The idea of this type of aid is not new,[2] but the means of accomplishing the desired results are considered novel and of interest technically.[3] Basically the system radiates two space patterns; one is circular and contains the carrier, while the other is a rotating sinusoid and contains only the sidebands corresponding to modulation of the above carrier by a monochromatic tone of low frequency. This latter pattern has a relative phase varying with azimuth (relative to the station). The receiver in the aircraft is designed to observe this phase and compare it to a fixed reference

he can fly along a radial to or from the station at the desired bearing of azimuth.

The combination of differential meter (cross-pointer instrument) and the phase shifter (known as azimuth selector) is not capable of distinguishing between a course and its reciprocal. An additional circuit is therefore provided to resolve this ambiguity by means of indicator lights.

It is of interest to note that an observer within range of two or more of these facilities can obtain not only his bearing with respect to any one of them, but also an absolute fix. Further, he can follow a course other than a radial one by obtaining absolute fixes at successive stages of the journey and navigating accordingly. An automatic means for doing just this is in process of final design and is expected to be available within the next year or two. The equipment required is DME (distance measuring equipment) and a computer for transforming the available observations into visual navigational indications. This is such that the cross-pointer instrument will show on-course as long as aircraft is flying the predetermined course. Deviations from this course will result in corresponding deflections of the meter.

Antenna Site Requirements

The siting requirements to insure satisfactory performance are definite, of course, but can usually be met adequately. There must be no obstructions between the transmitting and receiving antennas. This is basic to these and all higher frequencies. The ground contours and characteristics within a radius of 500 to 1,000 feet of the transmitting antenna are the most vital factors.

Ideally, therefore, a site should be flat to within 20 or 30 feet for a radius of 500 to 1,000 feet, and no obstructions within line of sight should rise more than 2 degrees above the horizon of the antenna. In practice these requirements are rarely fully met but they constitute a guide for survey parties. Actually these facilities have been installed and have been operating satisfactorily between Las Vegas, Nevada and Denver, and between Chicago and New York. The terrain encountered on these two routes is quite typical of bad siting conditions.

Ground Station Equipment

A block diagram for the ground station is shown in Fig. 1B. The antenna elements are horizontal loops of relatively wide metallic strips, so designed[1] that the current around the loop is approximately constant in amplitude and phase and takes the directions indicated in Fig. 1C. The diameter of the loop is in the order of magnitude of $\lambda/4$. Under these conditions, the polarization of the electric field is almost wholly horizontal and the horizontal space pattern is circular. The latter, however, is distorted by the proximity of the four radiators required to minimize octantal error. By proper orientation of the loops relative to each other, the octantal error practically vanishes. Figure 1D shows the actual array, with the carrier loop in the center of and above the sideband array.

The r-f lines to the antenna system, which is located on a 30-foot counterpoise about thirty feet above the ground, are of the solid dielectric type such as RG-8/U. They are all precut to provide the proper phasing and matching.

The sideband energy is obtained by means of a rotating capacitance goniometer (Fig. 2), essentially a capacitor in which the distance between the plates is constant, but the effective area A varies sinusoidally with time so that capacitance $C = kA = K\sin pt$. Thus the current through the capacitor at a frequency $\omega/2\pi$ is $I = k\omega E \sin pt \sin \omega t$, which represents the sidebands resulting from modulating a signal of frequency $\omega/2\pi$ by one of $p/2\pi$ or vice versa.

It has been found desirable to maintain $p/2\pi$ at a low value, in this case 30 cps. This is obtained by driving the goniometer rotor at 1,800 rpm. Inasmuch as the phase of this modulation will ultimately (in the receiver) be compared to a reference phase, it is essential that the reference signal be strictly constant in phase and of the same frequency as the variable phase signal.

To insure constancy of phase, the reference signal is generated by a magnetic tone wheel mounted on the same shaft as the goniometer rotor. This wheel has teeth cut in its periphery, of a shape to represent (at 1,800 rpm) a 10-kc wave frequency-modulated at 30 cps. The wheel is driven in a magnetic circuit, varying its reluctance in the above manner and generating a corresponding emf. This latter then is used through appropriate amplifiers to amplitude-modulate the carrier signal fed to the center loop of the array. In this way, the reference and variable-phase signals are maintained in proper synchronism despite minor variations in primary power frequency or goniometer speed.

In one type of goniometer assembly, a phase adjustment permits setting the desired angle between the tone wheel and the goniometer rotor. The rest of the structure serves to provide the desired

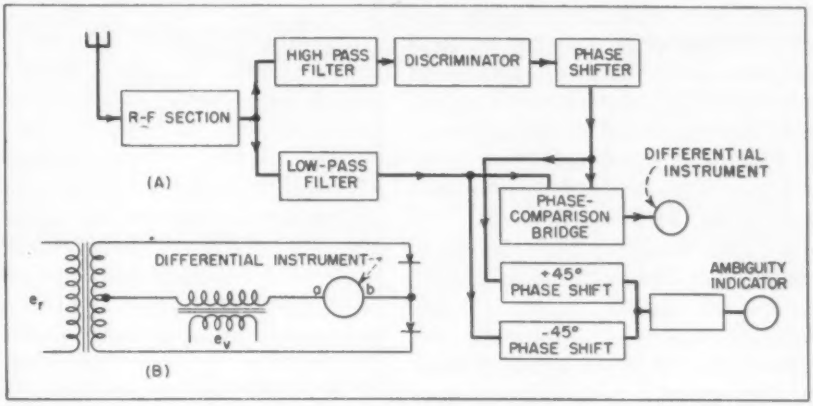


FIG. 4—Block diagram of a-f section of vhf range receiver, and circuit detail of differential zero-center meter that provides on-course information for the pilot

phase, thereby providing an indication of azimuth.

The reference phase signal is obtained by modulating the carrier with a subcarrier which is in turn frequency-modulated by the monotone referred to above. By this means the reference and variable-phase signals can be conveniently separated in the receiver. The carrier pattern is nondirectional and its phase does not vary with azimuth, hence the modulation on the subcarrier can be used as a reference.

The radiation pattern for the sidebands is obtained by the use of two pairs of so-called point sources at right angles to each other and in the form of a square as shown in Fig. 1A. The two radiators of each pair are fed in phase opposition and the two pairs are fed in phase quadrature. At a distant point P in space, therefore, the field due to the pair aa' will be $kI\sin(\delta\cos\theta)\sin pt$ and that due to the pair bb' will be $kI\sin(\delta\sin\theta)\cos pt$ assuming the same current amplitude in both pairs. The total sideband field will therefore be $E_s = A \sin(pt + \beta)$, where $A \equiv kI\,[\sin^2(\delta\cos\theta) + \sin^2(\delta\sin\theta)]^{\frac{1}{2}}$ and $\beta \equiv \tan^{-1}[\sin(\delta\sin\theta)/\sin(\delta\cos\theta)]$. If δ is very small so that $\sin(\delta\sin\theta) \rightarrow \delta\sin\theta$, then $E_s = kI\,\delta\sin(pt + \theta)$.

The relative phase of E_s is the same as the azimuth θ and the latter can be observed by measuring the former. For any practicable value of δ, the phase β will vary somewhat from θ, and $|\beta - \theta|$ is known as the octantal error due to the fact that

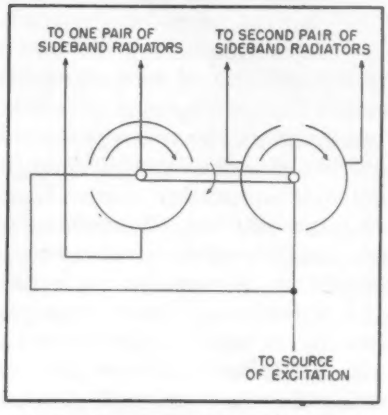


FIG. 2—Arrangement of rotating capacitance goniometer used to obtain sideband energy for vhf range

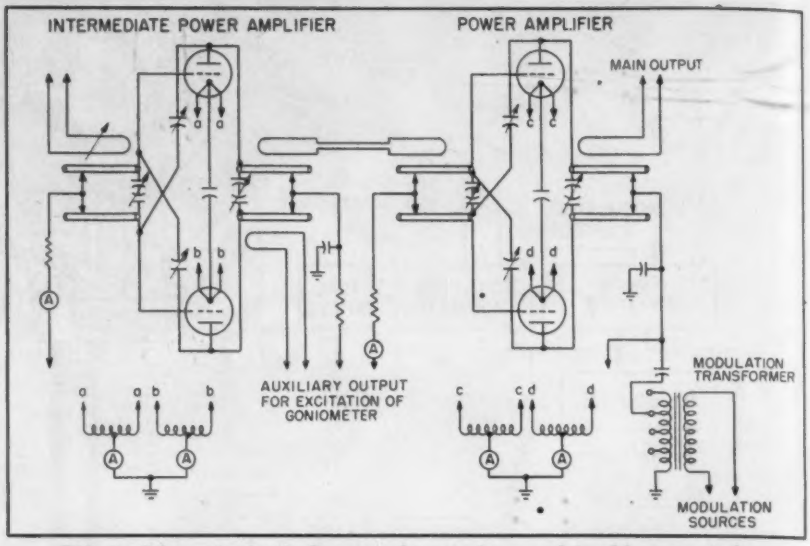


FIG. 3—Schematic circuit diagram of transmitter used in vhf range station

it varies from zero to its maximum within one octant of azimuth. It is evidently zero for all values of θ for which $\sin\theta = \cos\theta$, or for which $\sin\theta$ or $\cos\theta$ vanishes. Hence there is no error at $\theta = 0, \frac{\pi}{4}, \frac{\pi}{2}, \ldots$, and the maximum error lies between these points. This maximum error is, as pointed out, a function of δ. It is approximately 2 degrees for the spacing actually used (somewhat over 50 degrees), based on an array of four independent point sources.

In practice each radiator consists of a magnetic dipole of considerable dimensions and the close spacing results in a very appreciable coupling between antennas. This affects the radiated patterns and hence the octantal error. It has been found that by judicious arrangement of the radiators the octantal error is reduced to a practically unobservable magnitude. This is desirable, even though octantal error would be a fixed characteristic of the station and could be easily taken into account in the published charts.

The carrier with its several modulations, including reference signal and voice, is radiated by a separate antenna, also a magnetic dipole, located at the center of the sideband array but at a higher or lower horizontal plane for mechanical reasons.

In the receiver, the signals from the sideband and carrier antennas combine to produce a modulated signal which is then normally processed, through rectification, back to the original audio monotone, but it will now have a relative phase depending on the azimuth of the receiving antenna relative to transmitter. The frequency-modulated signal on the carrier is, after first detection, handled separately and ultimately converted also to its original audio frequency. The receiver thus reproduces the original monotone but in two parts, one of constant phase and the other of variable relative phase.

These two components are then fed into a circuit for comparing phases. Equality of amplitude and phase results in zero deflection in a d-c differential meter. A calibrated phase shifter is further used with the reference signal so that its phase may always be adjusted relative to that of the variable phase component. In this manner the latter, and hence the azimuth, can be measured.

Use of Range Signals

The vhf range facility may thus be used in two ways. The observer may determine his azimuth from the station by adjusting his phase shifter until the indicator shows zero deflection (so the two signals are in proper phase, and he is on course), or he may set the phase shifter for a predetermined value of azimuth and then navigate so as to keep on course as shown by the differential meter. In this manner,

The equisignal localizer has already been described. A more desirable form has now been evolved, however, which is scheduled to supersede the previous method completely. This is the so-called phase-comparison localizer (Fig. 6A). As its name implies, its use depends on the comparison of the relative phase between two signals.

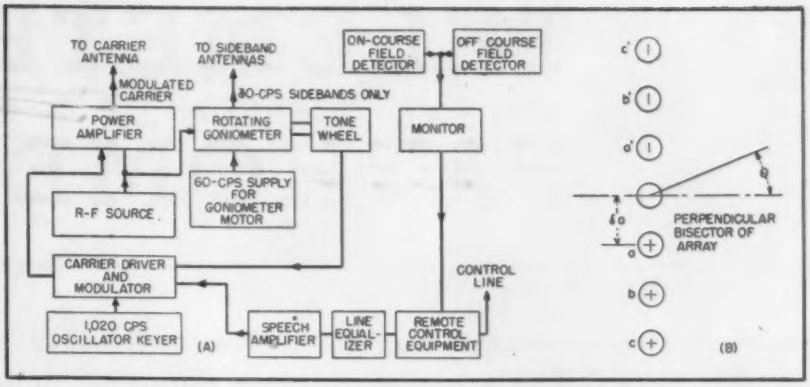


FIG. 6—Block diagram of phase-comparison localizer that is scheduled to replace equisignal localizers now being used in ILS, and detail of antenna array used

Phase-Comparison Localizer

The antenna system is the same as that of the equisignal type, that is, a nondirectional radiator for the carrier, and one or more pairs of radiators for the sidebands—all in a symmetrical linear array. The sideband radiators on one side of the carrier antenna are, as before, in opposite phase to those on the other side. The only real difference between this and the equisignal type is in the fact that the carrier is modulated by a subcarrier which is itself frequency-modulated by a low-frequency tone. (The arrangement is, in fact, identical to that used in the vhf omnidirectional range.) Sidebands corresponding to this same low-frequency tone are impressed on the other radiators.

As a result of the phasing of the sideband radiators, each pair will produce a horizontal space pattern having a null and consequently a phase reversal along the perpendicular bisector of the array. Referring to Fig. 6B, for each pair the expression for the field is of the form $e = kI\sin(\delta\sin\theta)$. Obviously the field for $\theta = \theta$ is exactly equal but opposite in phase to that for $\theta = -\theta$, and vanishes for $\theta = 0$.

In the receiver, the signal corresponding to the sidebands just mentioned is combined with the reference signal in the bridge circuit described in connection with the omnirange receiver. Thus if e_v is in phase with e_r, the voltage applied to the differential instrument (Fig. 4B) is from b to a and the pointer deflects to one side. If the relative phases are reversed, the voltage will be from a to b and the pointer deflects to the other side. If $e_v = 0$, the current through the instrument is zero and there is no deflection. The circuitry and operation, and hence the equipment (in the aircraft) is the same as for the omnirange. From a practical viewpoint this is a powerful recommendation for the phase-comparison localizer.

In the ground equipment this type of localizer represents a considerable simplification over the equisignal type and a further standardization of apparatus. The goniometer is in fact used, but in this case the inactive set of plates is connected to a dummy load to maintain balance. As in the equisignal type, the carrier can be modulated with voice and identification.

In practice, the phase-comparison type of localizer provides the same performance as the equisignal, but with appreciably greater ease of maintenance and hence greater reliability and efficiency of operation. These considerations have led to the adoption of this form as the CAA standard. It will replace the equisignal type as soon as the flying public is more generally equipped with proper receivers. It is also scheduled by ICAO to be the international system, waiting only for more widespread availability of receiving equipment.

VHF Communication

With respect to air-ground-air communication there is no special technique involved, the equipment being of standard design. All of this communication as well as the vhf navigation aids are within the band from 108 to 132 mc and the airborne receiver used for the navigation aids is designed to cover the entire band for communication as well.

There are also voice channels on both the runway localizer and the omnirange, which are used generally for traffic control and weather information. At the present time, consideration is being given to utilizing a very narrow portion of the above spectrum for continuous weather broadcasting. The operator would record weather information on a continuous tape which then would be run through the transmitter. This has not yet been worked out operationally.

Conclusion

This paper is confined to the matter described by the title. But it is not to be inferred that no work is being done on newer, promising techniques to accomplish the above results a little better or more economically. Both laboratory and field tests have been in progress for some time on new ideas and devices, particularly those depending on pulse techniques.

The CAA has the statutory obligation of providing certain services continuously and reliably with the best means available. It, therefore, cannot adopt various new devices before they are suitable for use in civil operations of airways, nor can it discontinue its program of constantly improving service.

The CAA is working to provide always a better airway aids service to a constantly expanding civil aviation, which in turn means better service to a large and vital segment of military aviation in time of emergency.

References

(1) P. Caporale, The CAA Instrument Landing System, ELECTRONICS, p 116, Feb. 1945 and p 128, March 1945.
(2) David G. C. Luck, An Omnidirectional Radio Range System, *RCA Review*, July 1941 and Jan. 1942.
(3) This facility has also been described, recently, by D. M. Stuart of CAA.

impedance relationships between various parts of the circuit.

The transmitter proper is essentially the same as described previously.[1] It is capable of providing a carrier output of at least 200 watts. Its final stage can be modulated up to 100 percent, though it is not so used here. The intermediate power amplifier has sufficient output at carrier frequency to provide energy to the goniometer as well as for excitation of the power amplifier stage.

Figure 3 is a schematic circuit diagram of the transmitter. The sideband power input to the goniometer is of the order of 20 watts. Of this about 11 watts is lost due to the fact that the goniometer is only 80 percent efficient and the antenna array only 60 percent efficient as a result of the close spacing of the elements. The remainder modulates the carrier (in the receiver) to a depth of 30 percent. (The reference phase signal modulation on the carrier is also 30 percent.) The rest of the transmitting equipment is of standard design adapted to the requirements peculiar to this service.

VHF Range Receiver

The receiver is, in the r-f portion, more or less standard. The a-f portion, however, separates the 10-kc subcarrier and the 30 cps derived from the sideband antenna. The two are carried along separately, the former going through the necessary demodulation circuits to recover the 30-cps reference signal, (shown in Fig. 4A) which is then passed through a special phase shifter. This consists of two transformer windings at right angles to each other and fed by two components of the reference signal which are in quadrature. A third winding rotates inside the first two and has a voltage induced in it with a phase dependent on its position relative to the two primaries.

In this manner, the reference signal may have its phase varied from zero to 360 degrees. From this instrument (the azimuth selector) the reference signal as well as the variable phase signal are fed into a bridge circuit (Fig. 4B) containing the differential zero-center meter (actually part of the cross-pointer instrument used in the instrument landing system.) The deflection of the meter will depend on the relative amplitude and phase of the variable phase signal e_v with respect to the reference e_r, zero deflection occurring only for quadrature phase relationship or one of the two components vanishing, or both. Hence if e_r and e_v are adjusted to be in quadrature at some azimuth, say θ_0, then the vector sum of e_r and e_v differs from the vector difference, the currents in the differential instrument do not balance, and a deflection occurs.

Since the two signals can be in quadrature twice in 360 degrees, an ambiguity results which is resolved by additional phase-shifting circuits together with a suitable indicator. With this one can tell whether the azimuth selector shows true bearing or its reciprocal.

Instrument Landing System

The standard CAA instrument landing system has been described elsewhere[1], and only those features not previously mentioned will be given here.

The markers are unchanged. It is anticipated, however, that they will be generally replaced by suitable distance-measuring equipment as soon as the latter is available. Installation of DME is expected to start in the fiscal year 1948.

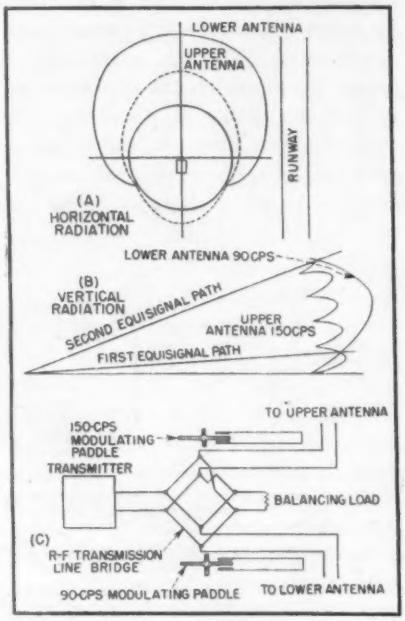


FIG. 5—Radiation patterns and modulating arrangement of 335-mc equisignal glide path transmitter used in standard CAA instrument landing system

The glide path operates at about 335 mc and is of the equisignal type using 90-cps and 150-cps modulations. The unmodulated carrier output is of the order of 25 watts. These two modulations are impressed on separate portions of the carrier, which are then fed to two vertically separated antennas. Each of the antennas produces a space pattern which is more or less circular in the horizontal plane, but multilobed in the vertical plane. The intersection of two of these lobes forms the equisignal surface used for a glide path. Figures 5A and 5B show these patterns. In the vertical plane there is a multiplicity of equisignal zones, the lowest being the one that is used. The antenna is designed so that the next lowest path is of the order of 15 or 20 degrees above the horizontal so that no possibility of confusion can exist. Instead of being perfectly circular, the horizontal patterns are compressed to the rear of the facility so as to minimize the effects of reflecting objects in that area, thus easing site requirements.

The actual glide path is the intersection of the equisignal surface and the vertical plane containing the localizer course, this intersection being hyperbolic. In practice the upper antenna is composed of two elements, one above the other and spaced one-half wavelength, so that actually three vertically stacked radiators comprise the antenna system. By adjusting the spacing between the upper and lower portions and by varying the relative powers fed to the two portions, the patterns can be controlled sufficiently to permit a variation of two or three degrees in the inclination of the glide path.

Splitting of the carrier into two portions and modulating of each portion with its proper tone is accomplished in the present equipment by means of transmission-line bridges together with mechanical variation of line impedances, as shown in Fig. 5C.

The receiving equipment is very similar to the localizer receiver[1] except for differences dictated by the different radio frequency.

TELEMETERING FATHOMETER

Modified radio equipment serves to link sections of a standard Navy fathometer to secure continuous depth indications beneath a remote-controlled pilotless ship. Radio frequencies near 8 and 70 megacycles are employed

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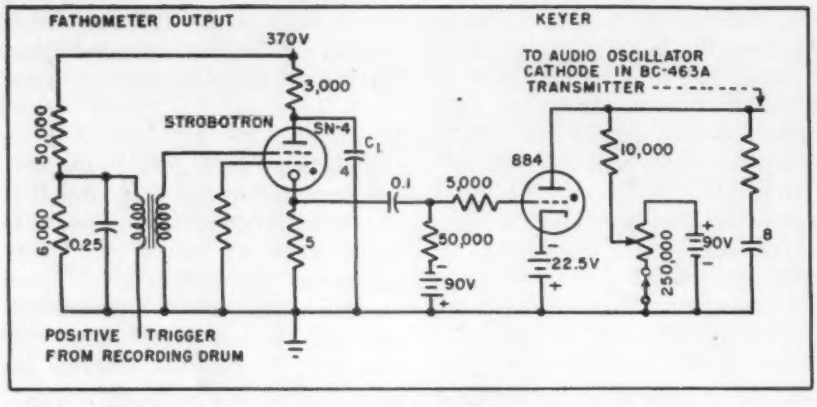


FIG. 1—Modified fathometer output circuit and keyer circuit used to modulate the control station transmitter

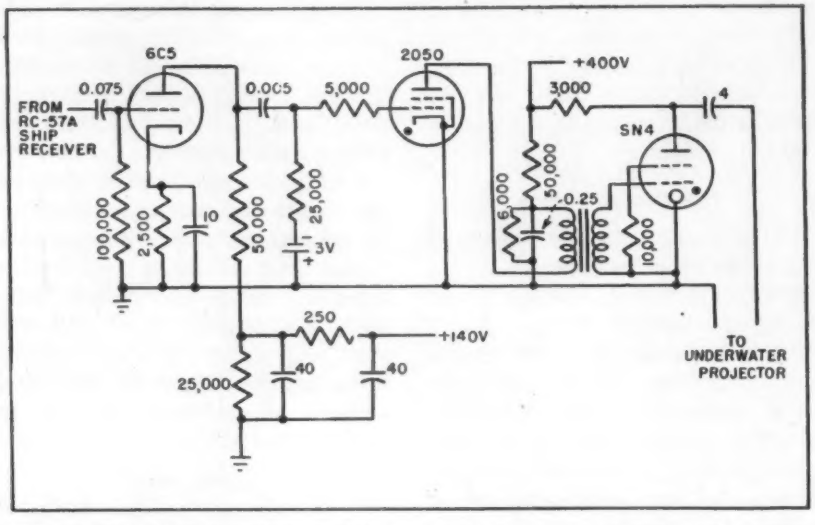


FIG. 2—Modified ship receiver output circuit used to translate received pulses from the control station into projector pulses for echo sounding

IN the remote control of ships, it is often desirable to observe continuously and record, on shore, numerous phenomena encountered by the controlled craft. As part of such a specific problem, it has been necessary to record the depth of water beneath a ship while it is being maneuvered. Existing electronic equipment was modified for the purpose, and its disposition is illustrated. The equipment used is divided into two groups, a transmitter, receiver, and recorder located at the control position on shore; and a transmitter, receiver, and depth-sounding equipment on the mobile ship.

The control station may be considered as a closed radio and wire circuit in which impulses initiated by a portable fathometer-recorder equipment are received after a variable time delay (due to the time required for the sound to travel through the water); this delay is plotted by the recorder in terms of ocean depth.

The ship equipment consists of an ultrasonic projector triggered from the shore, and an ultrasonic hydrophone that sends back the desired time-delay information. A radio receiver and transmitter are also necessary to tie this underwater transducer equipment into the closed radio circuit of the control station.

For a telemetering system in which the measurement of small time intervals gives the desired information, the radio links and trigger mechanism must contain only small, fixed, known time delays, and as a corollary, the bandwidths of the system must be sufficient to pass the required sharp pulses without unduly modifying their steepness.

The standard Navy type NK-2

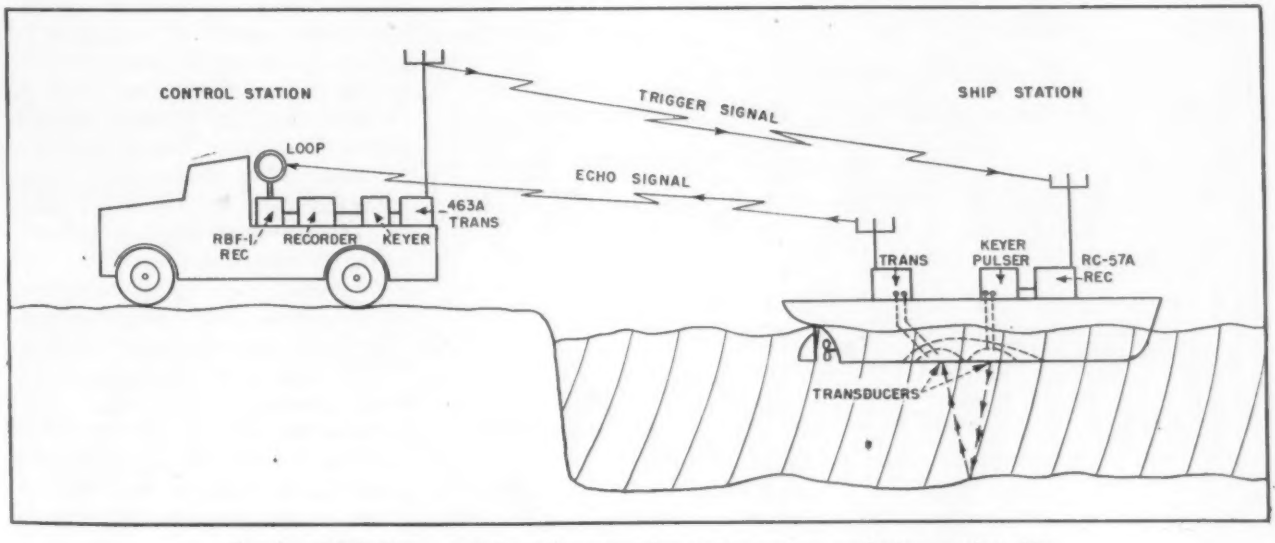
Control equipment includes the RBF-1 converted f-m receiver and loop at left, modified NK-2 recorder and the keyer. The BC-463A transmitter is at the rear

Ship station equipment. The housing at top contains projector and hydrophone. Amplifier and transmitter, the keyer pulser, and the RC-57A superregenerative receiver are in the front

fathometer that was modified for telemetering normally functions as follows: A 12-v storage battery supplies power to a centrifugal governor-controlled motor. Through suitable gearing, this motor drives a drum which has a single turn of wire mounted in a spiral groove along its face. The wire projects approximately half its diameter (0.026 in.) above the surface of the drum face. A similar mechanism is used in facsimile receivers. Friction rolls drive the arc-discharge type recording paper across the face of the drum. Above the paper, and lightly contacting it, a printer strip is mounted parallel to the longitudinal axis of the drum. As the drum revolves, the point of contact between the printer strip, the paper, and the spiral wire moves at uniform speed across the paper. At the instant the point of contact passes a reference line near one edge of the paper, a pulse is transmitted into the water by discharging a capacitor into the projector unit of the transducer.

The pulse in the water travels to the bottom, where it is reflected, and the echo is intercepted by the hydrophone unit of the transducer. The signal from the hydrophone is passed through a high-gain amplifier and is then fed to the printer strip. The signal causes an arc discharge to take place from the strip through the paper to the spiral on the drum. The point of contact between strip and spiral depends upon the elapsed time taken by the pulse during its travel through the water.

The paper is graduated in feet, and the depth of water may be read



Complete block diagram of the fathometer telemetering system employing a robot ship

directly from the recording. The range of scale is directly proportional to the rotational speed of the spiral drum. A suitable gear-shifting mechanism provides a selection of ranges.

The triggering contacts consists of a stationary brush and a rotary segment mounted on the end of the spiral drum shaft. The stationary brush position is adjustable to provide alignment between pulse and index line on the recording paper.

The modified output of the fathometer recorder is shown in Fig. 1. As originally wired, the cathode of the type SN-4 strobotron was tied directly to ground and the tube normally functioned to discharge capacitor C_1 through the projector to generate the underwater pulse. Because the length of the impulse was insufficient to key the audio oscillator of the modified BC-468A transmitter, the 884 gas-tube circuit was added. By inserting a 5-ohm resistor in the cathode circuit of the strobotron, sufficient voltage is developed across it when the tube fires to trigger the 884 tube.

The RC networks have been chosen to give proper time constants for the desired keying interval. It was found necessary to insert the battery in the cathode circuit of the 884 tube to balance out the drop through the thyratron that was sufficient to bias the transmitter audio oscillator to cutoff. It was found necessary to prevent strong sunlight from falling directly on the strobotron since sunlight caused the tube to remain continuously ionized.

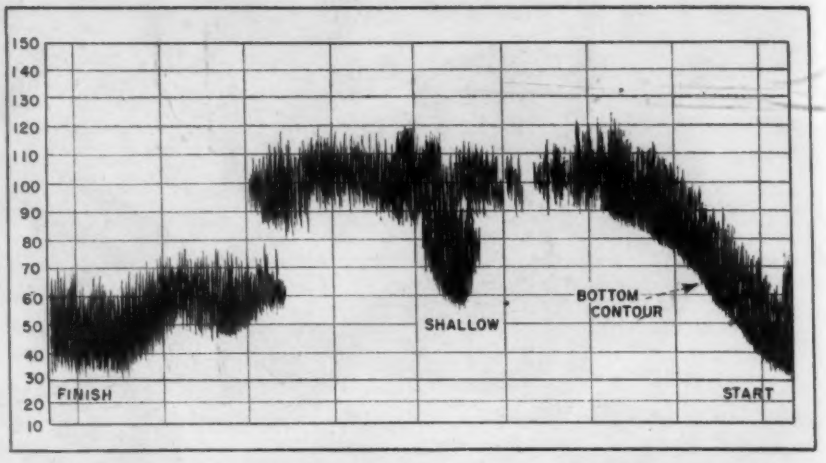


FIG. 4—Drawing showing the salient features of a record obtained from trial run of the robot ship. From right to left, the contours revealed by echo soundings indicate the cruise from shore to deep water and back

The RBF-1 f-m receiver was chosen for use at the control station to receive the incoming signal from the low-power ship transmitter and operate the recorder. The circuit was modified for a-m reception by converting the limiters to additional i-f amplifiers and the discriminator was changed to a diode-type detector. The necessary bandwidth required for pulse reception was inherent in the original f-m design. For use in proximity to the control transmitter it was found advisable to construct an electrostatically shielded loop, suitably placed and oriented. The antenna was made by fastening a length of RG-11/U concentric cable, in the shape of a closed, one-turn loop, to a piece of plywood. The inner conductor was soldered to the outer sheath at the closure point.

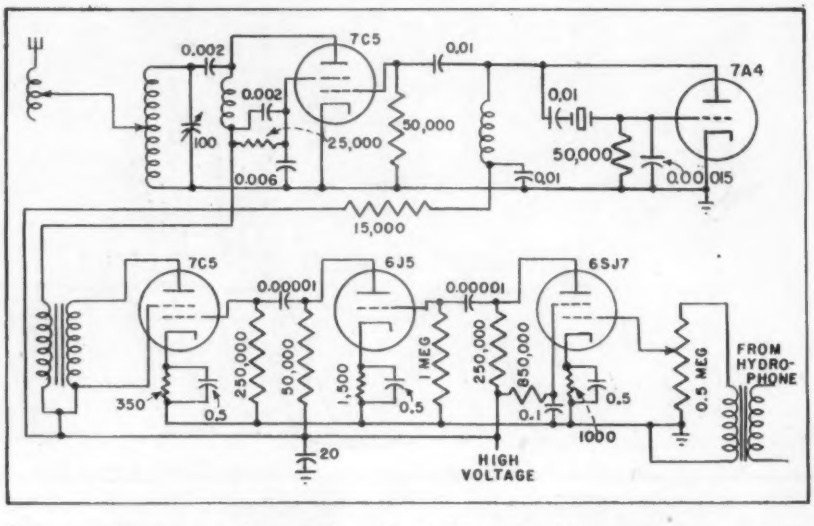


FIG. 3—Hydrophone audio amplifier and ship transmitter that sends back received echoes from ocean bottom to the control station recording equipment

Ship Station Equipment

The receiver employed at the mobile station to operate the transducer projector is the RC-57A superregenerative type, the circuit for which appears on page 89 of the December 1946 issue of ELECTRONICS. It tunes in the frequency band 67 to 72 megacycles.

Figure 2 shows a keyer-pulser that was built to convert the negative output pulse from the receiver to a capacitor discharge into the transducer projector. The circuit uses a type 6C5 phase-reversing amplifier to trigger the type-2050 thyratron. It was found that although the gas tube would fire from a negative pulse, a delay of several milliseconds occurred. It apparently requires considerably more time to transfer an arc between control grid and cathode to the anode when the cathode is negative than it does when the cathode is positive since the cathode must reverse polarity in the former case.

The echo picked up by the hydrophone is fed to the amplifier and transmitter shown schematically in Fig. 3. The unit is essentially an audio amplifier modulating a 5-watt a-m transmitter with a carrier frequency of 8 megacycles. A band of audio frequencies from 600 to 16,000 cycles can be successfully transmitted.

A sample record of a trial run is shown in Fig. 4.

Initial production model of the magnetic tape recorder. Tape runs from left to right. The recording, erasing, and playback head is front and center

Magnetic Tape Recorder for Movies and Radio

New equipment using improved tape driven by three motors at a speed of thirty inches a second has an overall response flat within 4 db from 32 to 9,600 cycles. Overall design considerations and circuits for the recorder-reproducer are shown and a word spotter for editing is described

By RICHARD H. RANGER

President, Rangertone, Inc., Newark, N. J.

THE BASIC FACTORS underlying the magnetizing of ferrous wires as a means of recording, storing, and later reproducing intelligence have been known since the turn of the century, and more recently the expansion of the technique to include ferrous oxides on paper or plastic tapes has been well developed[1].

In Germany, magnetic tape recordings were used by broadcast stations and the military during the war. The technique was probably developed to its highest point in the so-called K-7 Magnetophone manufactured by Allgemeine Elektrische Gesellschaft. The recordings consist essentially of iron rust supported on a synthetic tape of great inherent physical strength. The tapes pass rapidly and uniformly by erase, record, and pick-up heads.

A method of using a frequency in the order of 100 kilocycles as a means of erasing and preparing tape for recording audio currents has been worked out to give a quality of reproduction not heretofore approached. Using an early model Magnetophone and what information has become available in the United States through reports of Army Intelligence missions[2], to-

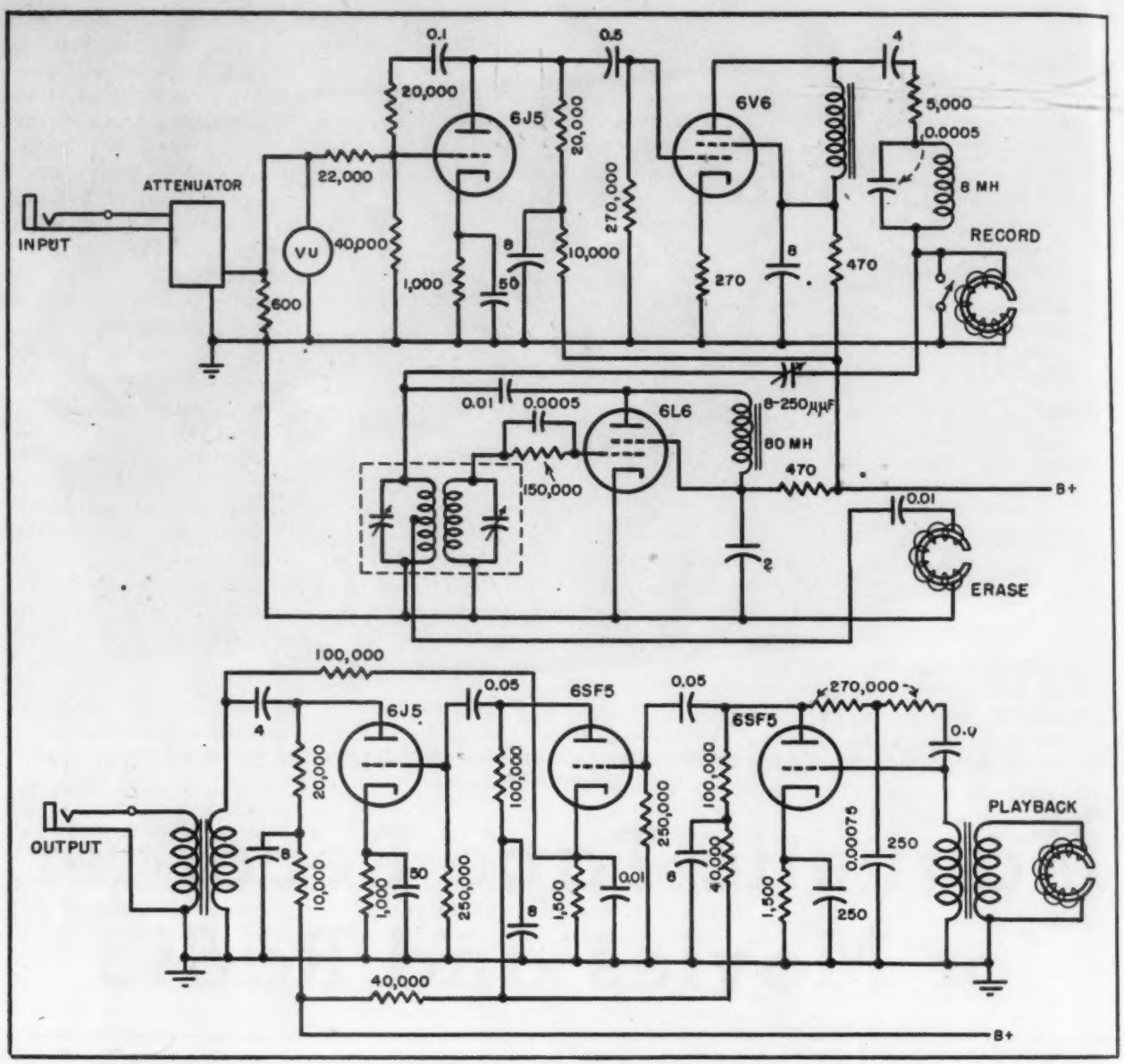


FIG. 1—Circuit diagram of the recorder-reproducer, showing method of energizing record and erase heads

gether with American laboratory and production methods, a new recorder-reproducer has been built that matches or surpasses its predecessors in every detail.

With a view to manufacturing a professional machine, the first production model has been constructed along the lines illustrated, using the circuits shown in Fig. 1. The main elements in the equipment are the erase, record, and play-back heads; the tape; the amplifiers; and the drive mechanism. The play-back head is the most critical of the three because signals recorded on the tape are of low intensity. It requires 70 db of amplification to bring the peak recorded signals up to 0 db. Since the dynamic range possible with tape recording approaches 60 db, the very weakest signals are down some 130 db in the levels only a little above the thermal noise of tubes.

Construction of the Heads

In Germany and America, the development of high permeability materials has been carried farther than anywhere else, and therefore, the materials for making the heads have been available. The head in Fig. 2 is made in two halves from laminated high permeability material 6 mils thick. The width of the pole pieces is greater than the quarter-inch width of the tape to allow for slight sidewise excursions of the tape in passing. The actual gap in the head is small, being in the order of 0.4 mil across. The gap itself is filled with a nonmagnetic shim of beryllium copper. The windings and impedances of these heads are as shown in Table I.

For the erase operation, the current required is determined largely by the magnetic properties of the tape used. With one of the ferric oxide tapes some 80 milliamperes of 70-kc energy is necessary to do a thorough demagnetizing job.

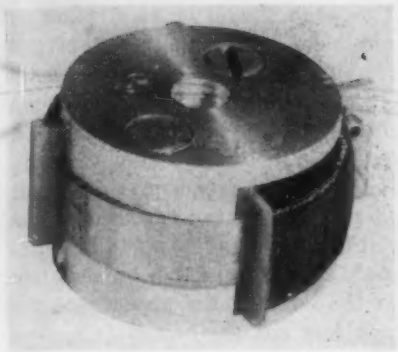


FIG. 2—Typical recording head removed from the assembly

The ferrous oxide tapes, current in the States, and especially the nickel-irons require much stronger erase current fields. Although the remanence and coercive force of these latter materials is far greater (this would appear to be an advantage for greater permanency) it has been found that the lower values of red oxide were better from the point of view of quality linear response. It is interesting to note that only red oxide made by oxidizing the ferrous black oxide is magnetically effective. The reasons are not known, but it is presumed that by slowly oxidizing the ferrous its lattice structure is maintained, which is presumed to hold the magnetic structure just enough to give a flexible medium.

Recording Bias

For the record head, an audio signal of 4 ma is combined with a high frequency bias of 1.5 to 2 ma for best results. The action of the bias current in improving the linearity of the magnetic remanence of the tape is shown in Fig. 3. Fig. 4A shows the remanence with varying recording current without the use of bias. This curve shows high irreversible areas, all of which indicate lack of linearity. Figure 4B shows the remanence with half the optimum bias, and Fig. 4C shows the remanence with full corrective action of the bias applied. Greater values of high frequency bias only have the effect of reducing the overall remanence,—in other words, erasing is beginning; so a definite optimum value exists. A little trick that seems to identify the correct bias, is that below the proper strength, the third harmonic is evident, and above the proper value, the fourth harmonic increases.

It must be realized that the tape is magnetized longitudinally by the variations of the magnetic force at the gap in the recording head. It is necessary for the tape to be in direct contact with the heads to obtain best results. The pressure of the tape on the heads must not, of course, be overdone, as the tape itself might be considered as a form of fine crocus cloth, and its action is always to give a beautiful finish to the heads.

The design of the core at the gap in the heads is such that the gap increases gradually in size as the head wears down. This means that the equipment will gradually show less response on the highs as playing time increases. The effect, however, is not noticeable for over 500 hours playing time, depending upon the degree of care exercised in the operation of the machine. A disengager is provided on the head assembly by means of which the tape is made to stand off from the heads in the rewind operation, or from the erase and record heads in the playback operation. The entire head assembly is plugged in with one operation, and each machine is furnished with two complete assemblies in order to take care of operational failure, besides providing a spare while a worn head is serviced. In servicing, the heads are taken apart, and re-assembled with new cores. This process is simple, but the lapping of the gap is a precision jeweler's job and involves the use of special jigs.

The function of the high permeability material is to concentrate a maximum of flux at the extreme edges of the gap. It is readily appreciated however, that the effective width of the gap, even with these materials, is determined by this concentration. Actually the magnetic gap is about 0.2 mil wider than the physical gap owing to the slight spreading of the crowded magnetic lines of force as they leave the iron core edges and pass through the tape.

Mechanical Tolerances

The actual alignment of the gap perpendicular to the motion of the tape is most critical. A slight er-

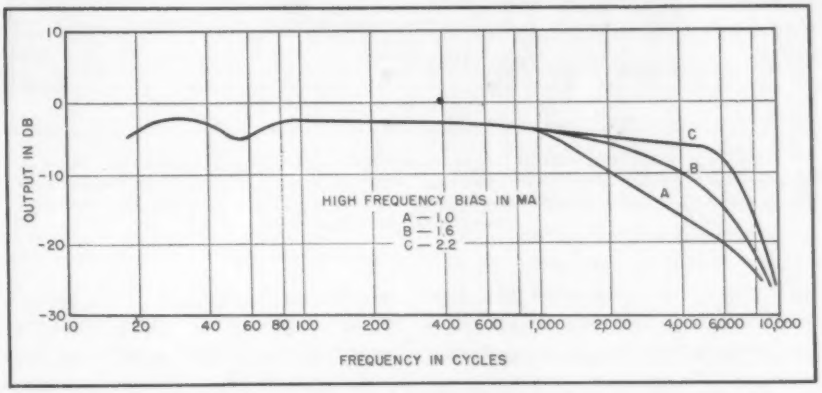


FIG. 3—Effect of bias current in improving linearity of magnetic remanence of tape

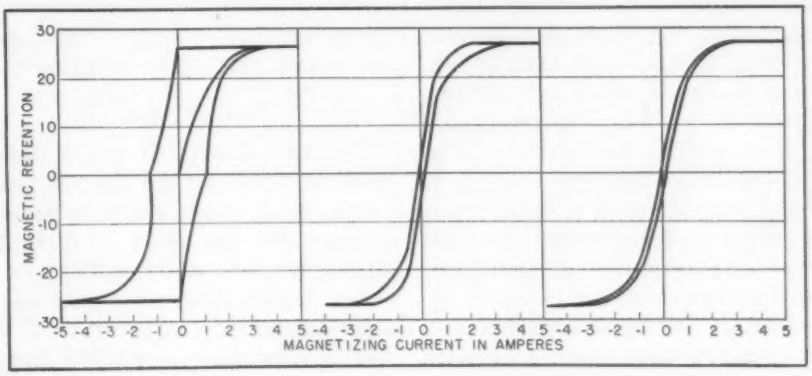


FIG. 4—(A) magnetic remanence with varying record current and no bias: (B) remanence with half optimum bias current: (C) remanence with full corrective bias

the recording head is shown in Fig. 5A. The response rises to a maximum around 1,000 cycles in a head loaded for 50 ohms. For an unloaded recording head, maximum response will occur at about 4,000 cycles. The play-back amplifier is therefore compensated for these conditions so that its response follows curve B. The final result of the overall recording and reproducing amplifiers is shown in curve C.

Tape Drive

It is essential that constant tape speed be maintained. Three motors are employed to insure constant tension at all points in the tape path. One of these motors is to the left and on normal playing it controls the release of the tape reel. It must oppose this release with a torque fairly constant from start to finish. The second motor is synchronous and holds the tape rigorously to the rotational speed of this motor by means of a sleeve on its shaft which presses against a rubber idler. The third motor is on the right and drives the take-up reel. As the reel builds up in diameter with the successive layers of tape the moment arm increases with the radius; the larger the reel the slower the rotation. These two facts show the necessary relation between rotational torque of the motor and speed. It is necessary for the motor drive on both the tape take-up and release spools to have a curve of torque inversely proportional to the speed of the reel. Although it has not been possible as yet to obtain a straight-line function for this curve, modification of the rotors of normal capacitor start and run motors has resulted in the characteristic indicated in Fig. 6. Whatever the rotational torque of the motor, the pull on the tape will decrease with increasing radius.

THE VALUE OF MAGNETIC TAPE RECORDING

Interest in magnetic tape recorders is particularly high among three groups.

Film makers are eager to explore the possibility of using magnetic tape as a simpler, cheaper means of recording, editing, and dubbing in the eventual sound track of sound movies.

The success in recording one prominent radio show has led to strong pressure by other artists for similar handling of their productions.

F-M broadcasters, dependent in many cases upon recorded music for the bulk of their present programming, have also taken a keen interest in magnetic tape

Editing Aid

Use of the equipment for broadcast or sound-track dubbing has been greatly enhanced by the recent development of a "word-spotter". Still in the experimental stage, the device has been arranged to plug in, replacing the conventional head assembly, and is driven by the sync motor spindle and rubber idler that customarily pulls the tape. The large driven drum of the spotter has a circumferential groove slightly wider than the tape. A playback head is mounted flush on the edge of the drum, so that if a short length of the tape is held stationary in the groove, musical chords, syllables or short words are repeated over and over. By this means it is easily possible to spot desired portions of a recording with uncanny accuracy.

Experiments now in progress indicate that the machine may prove useful as a memory device for computer systems, since the shelf life of magnetic wires and tapes has so far proved to be indefinitely long. In order to eliminate errors resulting from possible cold flow of the plastic tape used as the base for the magnetic powder, investigations are being made of Fiberglas tape as a support for the recording medium.

Table I—Head Characteristics

Head	Turns	Resistance (ohms)	Impedance (ohms)
Erase	100	1	2,000
Record	600	10	11,000 at 70 kc 560 at 1 kc 58 at 100 cycles
Play-back	600	10	560 at 1 kc 58 at 100 cycles

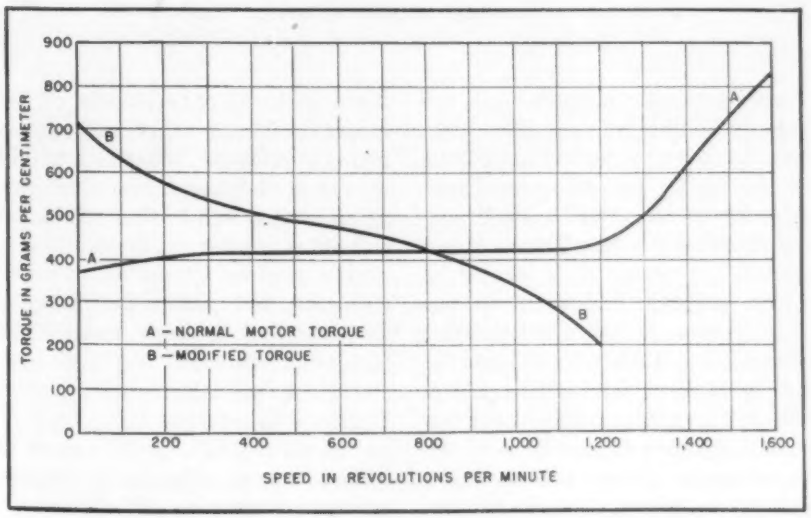


FIG. 6—Modifications in the torque characteristics of motors for recorders

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(1) M. C. Selby, Investigation of Magnetic Tape Recorders (including bibliography) ELECTRONICS, p 133, May 1944.
(2) A Bibliography of OTS Reports on Magnetic Tape Recorders (a free publication) Reference Service Section, Office of Technical Services, Department of Commerce, Washington 25, D. C.

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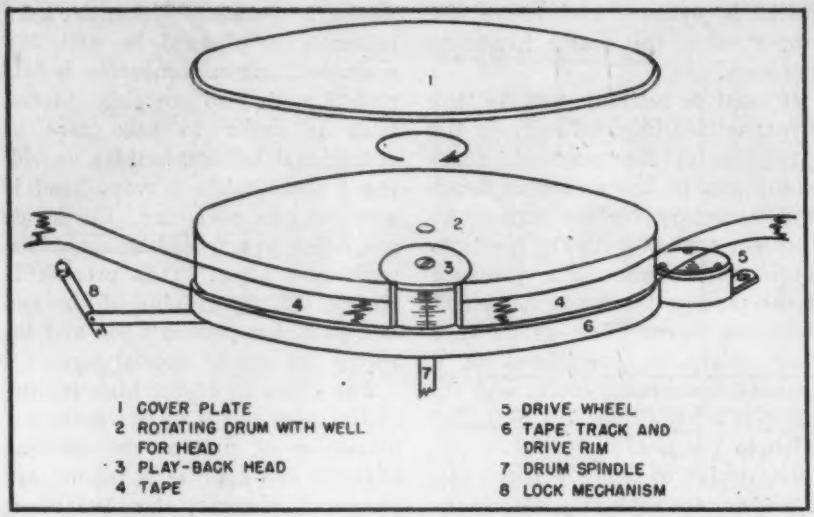
(1) Magnetic Sound for Amateur Movies, ELECTRONICS, p 140, March 1947.
(2) R. H. Ranger, Design of Magnetic Tape Recorders, Tele-Tech, p 56, August 1947.



Artist's sketch of the word-spotter that can be plugged in replacing the triple head. A still newer device will operate in two different ways: with the play-back head stationary and the tape moving normally by, or with the head revolving past the stationary tape

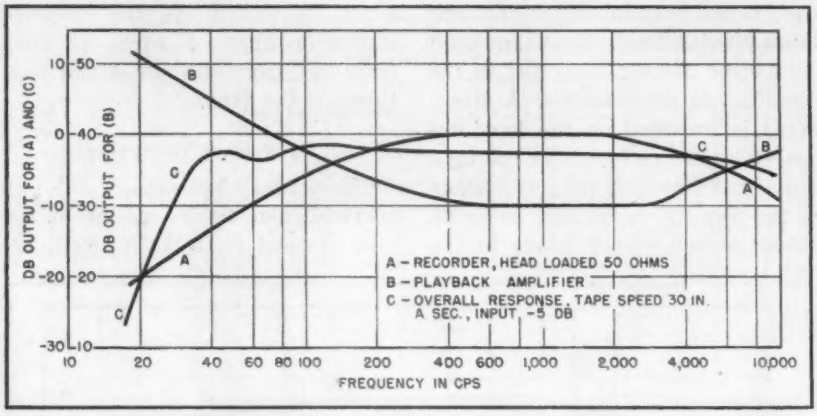


FIG. 5—Component and overall response curves for the magnetic tape unit. Curve A shows the recorder alone with no input equalization. The amplifier response is superimposed in curve B (note the different vertical coordinates); while the combined response is given in C

ror in this alignment will easily result in a variation equivalent to the width of the gap across the quarter-inch tape. This alignment can be achieved through the use of a microscope set up with sturdy longitudinal and vertical movement controls. Actual alignment adjustment is made by screw adjustments on the top of the head assembly, and can be accomplished in the field with the tape in motion. For this purpose, a standard tape recorded at 6,000 cycles with 50 percent modulation is furnished. Adjustment can then be made by observing maximum response, and setting the adjustment screws to this position. With the pickup head adjusted it is then possible to align the record head. For this second check purpose, a blank tape is used, and recorded with a 6,000-cycle signal put on the recording head. The pickup head is not readjusted during this operation, but its maximum response is noted as the record head screw is adjusted.

Gap Spacings

The recording head has a normally wider gap than that of the pickup head. There seems to be an improvement in using a slightly larger gap than that in the playback. In recording, the signal laid down on the tape seems to be primarily a function of what is happening at the pole piece edge where the tape leaves the recording gap. This edge should be as straight as possible. The magnetism that will remain in the tape may be considered as a statistical average of the effects the tape has undergone, caused by both the audio recording and the high frequency bias as it passes through the gap fields. This statistical average is finally influenced more by the flux immediately on the edge of the gap where the tape last passes than it is at any other point.

This phenomenon has two beneficial results; it increases the free magnetomotive force ready to go up into the tape at the trailing edge, and it makes the resultant lines of force appear to pass up more vertically into the tape and thus increase the definition.

The alignment of the erasing head is not at all critical; it is 20 mils wide. In much the same manner as demagnetizing a watch, the purpose of the erase head is to create a rapidly alternating magnetic field that increases and decreases as the tape passes through it. In consequence the tape is left neutral magnetically. Noise on the tape is entirely a function of the statistical averaging of the so-called domains of magnetization, and where there is as thoroughly a random condition as possible, noise will be at a minimum. It is obvious that the high frequency bias accomplishes this same improvement in quality on recording, by leveling this statistical average to that value required to represent the desired audio response.

Equalization of Amplifiers

The amplifiers for this recording system have gone through considerable progressive evolution. Generally speaking, it appears that for the recording head virtually constant response with respect to frequency change is the optimum. However, there are some who believe that a slight increase for the low and high frequency may be desirable. For the play-back, however, post emphasis may be used to completely realize a straight line frequency response from whatever signal has been put on the tape. The actual response on a tape with no post emphasis, and recorded with a constant current input to

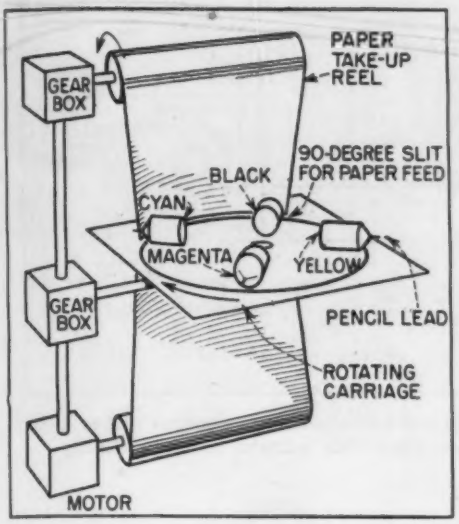


FIG. 2—Elements of the color printer

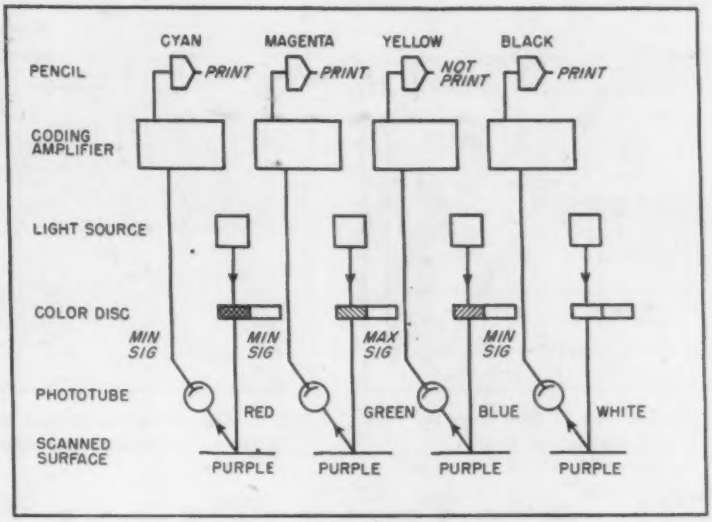


FIG. 3—Scanning sequence for a purple area.

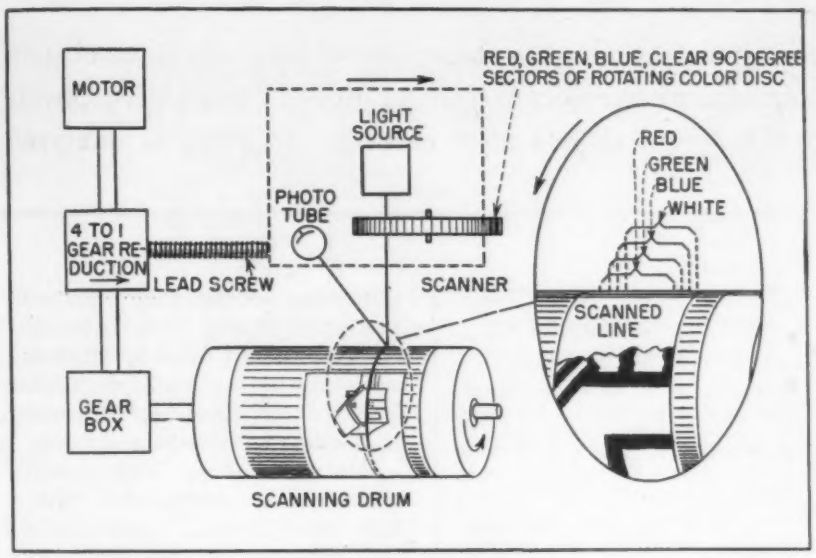


FIG. 1—Elements of the color facsimile transmitter. Each line area is scanned four times, once for each color. Expanded detail is approximate

essary, as in any system of facsimile, to maintain synchronism between transmitter and receiver and to feed paper past the rotating printer with its four actuating heads. Simply inserting black leads in each holder and increasing speed of paper feed by a factor of four converts the printer for normal black and white reception.

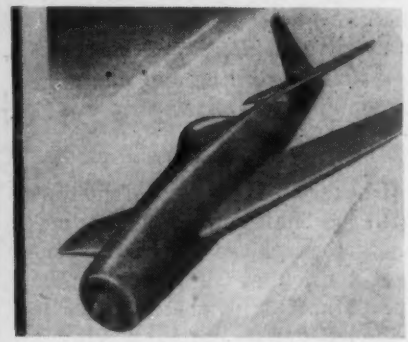
System Components

The elements of the color facsimile transmitter are shown in Fig. 1. The motor drives the scanning drum at a rate such that the same line element is covered four times by the light beam. However, as the drum revolves, red, green, blue and clear sectors of a color disc are interposed between the light source and the drum, one for each of the four periods of complete rotation. The magnified detail indicates approximately how a single line strip would be illuminated by different colored beams of light in succession. Light, or lack of it, is observed by the phototube, output from which is sent through an electronic conversion circuit and then to the receiver.

The receiver motor in Fig. 2 can be synchronized with the driving motor at the transmitter by any of the standard means. Further synchronization must be obtained between the color disc at the transmitter and the pencil drives on the rotating carriage at the receiver. Each of the recording pencil leads maintains a gentle pressure against the paper as the latter moves upwards at right angles to the plane of the arc described by the rotating carriage. When driving impulses are received, the pencil leads are pushed against the paper by an electromagnet for the duration of the impulse or series of impulses. Any or all the pencils can be energized. They are oriented so as to overprint each line, beginning with cyan (actuated, or not, by the red-light beam) and ending with black (connected through the clear-light circuit). Then the cycle begins again for the next line as the paper on the recording drum moves upward.

The simplified representation of Fig. 3 indicates system action when a purple area is viewed by the scanner. In this illustration probably all the recording pencils except yellow would be caused to operate, the colors combining to make a reasonable facsimile of the original colored area. —A. A. McK.

Colorfax experimental recorder disseminating color comics



Black and white reproduction of colored-drawing facsimile

COLOR FACSIMILE

Experimental system reproduces a colored picture by means of cyan, magenta, yellow, and black pencil leads on ordinary untreated paper. New recorder employed will achieve cheaper monochrome

A NEW, simplified facsimile receiver, invented by L. R. Philpott and W. G. H. Finch, has been developed as a color printer for use in a radio or wire reproducing system called Colorfax. Still in the development stage, the f-m receiver and printer combination may become available for home use in 1948 at a cost of about $100. It will be quickly adaptable to either monochrome or color broadcasts on f-m. For comparable transmission bandwidths the speed of reception for color will be a quarter that of black and white.

The experimental equipment built for demonstration on telephone lines prints colors at a rate of one-half inch a minute for a bandwidth not exceeding 1,800 cycles per second. Pictures are reproduced at the equivalent of 100 lines to the inch, as compared with newspaper color screens that are usually 65-line screen. The most important economic feature of the process is the fact that any paper fit to write upon can be used; special chemically treated stock is not needed.

The present limitation to the color process is the unavailability of entirely suitable colored leads for use in the recorder. This problem has not yet been vigorously attacked. Pictures transmitted by the experimental system are therefore lacking in strength and fidelity.

The color technique involves three main steps; analysis of the original by means of red, green, and blue color filters between a light source and phototube; electronic amplification and coding of the resultant currents; synthesis of color at the printer by means of cyan, magenta, and yellow pencil leads. The original is also scanned by plain light to operate a black pencil. Because each line of the original is scanned four times, any or all the pencil leads can be caused to operate, overprinting in most cases, to produce color combinations.

Supplementary equipment is nec-

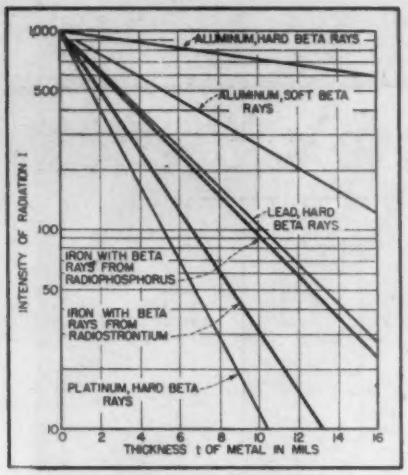


FIG. 1—Absorption of beta rays by various thicknesses of iron

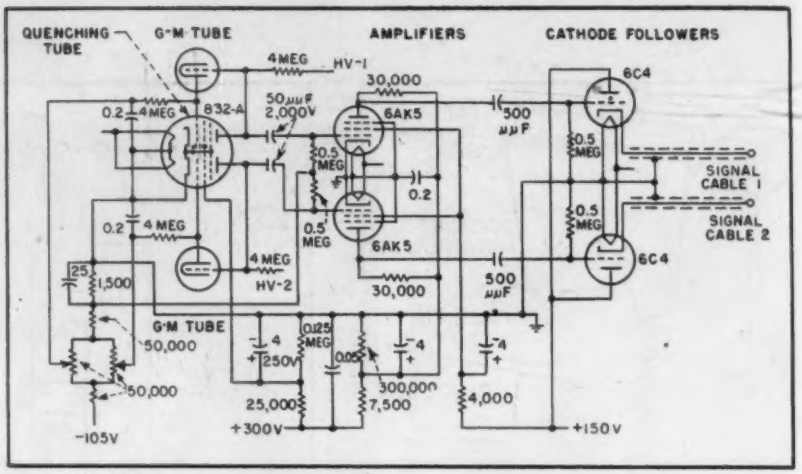


FIG. 2—Quenching circuit used for the two G-M tubes, with amplifiers and cathode followers for feeding into rate meter circuit that indicates thickness directly

Beta-Ray Thickness Gage

G-M counters and integrating circuits, responding to absorption of beta rays by steel strip moving over a radiostrontium source, measure thickness over range of 7 to 24 mils. Sheets can be sorted automatically by a mechanical gate after cutting. Accuracy is analyzed

A CONTINUOUS-READING beta-ray intensity meter was built for an application in which the thickness of a material was being measured by the absorption of beta rays. The problem arose in connection with the measurement of the thickness of steel in tinplate mills. A thickness gage which did not actually contact the material could be based upon the absorption of either x-rays or beta rays.

Beta rays are absorbed by a material in such a way that the transmitted intensity of the beam is a function of the initial intensity and energy and the composition and thickness of the material. The ratio of the transmitted to the incident intensity can be a measure of the thickness of homogeneous material, independent of the permeability or the conductivity.

Beta-Ray Sources

The available sources of high-energy beta rays are given in Table I. Radioactive strontium, which decreases to half its strength in 55 days, is ideal because of the lack of obscuring gamma-radiation. Measurements of absorption of beta rays in iron were made, using a Geiger-counter tube as a detector. The results are plotted in Fig. 1, along with data on other metals for comparison. The equations for each of these curves are $dI/I = a\ dt$, and $2.303 \log (I_0/I) = a\ t$. The absorption coefficient a is 0.346 per mil of iron for strontium $_{38}Sr^{90}$ (1.32 million electron volts or mev).

Table I also shows the rate at which the strength of radiostrontium decreases logarithmically with age. One might buy twice the strength needed for a specified job and replenish it every 55 days. This is particularly economical if a range of thicknesses is to be measured.

Detection of a high-strength source can be accomplished with a fluorescent screen, a photomultiplier tube, and an amplifier. For low intensities, however, the conventional detector is a thin-walled Geiger-counter tube, and such tubes were used in this work.

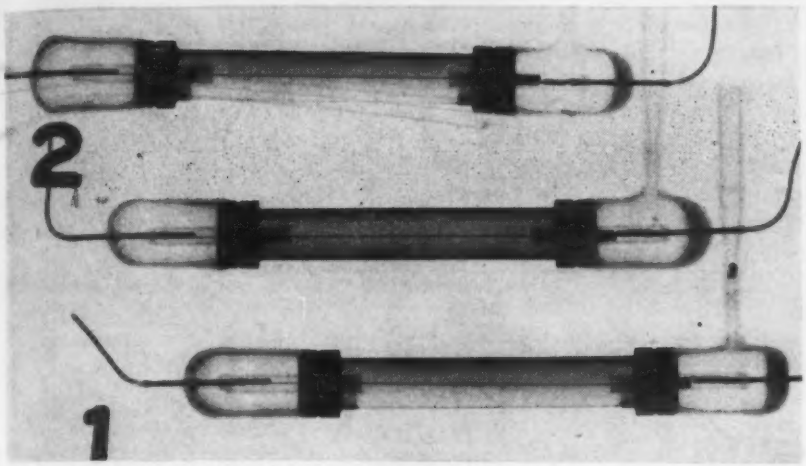
Thickness Gage

An intensity meter and thickness gage was built using two Geiger-counter tubes as beta-ray detectors, a conventional quenching circuit, pulse-shaping amplifiers, a pulse counter consisting of an averaging frequency meter, and a balancing circuit to indicate the change in average rate, with a meter to read directly the thickness change in thousandths of an inch (mils). The power supplies were regulated to minimize line fluctuation effects.

PUTTING NUCLEONICS TO WORK

Here is one of the first articles to give details for industrial utilization of products of the atomic pile, including specific circuits permitting application to a host of process control problems.

Radiostrontium and radiophosphorus for use as beta-ray sources can now be obtained from United States Atomic Energy Commission, Isotopes Branch, Box E, Oak Ridge, Tennessee.



X-ray picture of Geiger-counter beta-ray detectors using nickel envelopes. The thin wall on the lower side of each tube is three mils thick

for Sheet Steel

By OTTO J. M. SMITH

Research and Development Laboratory, Summit Corporation, Scranton, Pa.

The circuit of the quenching head is given in Fig. 2. The G-M tubes and amplifier tubes in the measuring head were mounted on rubber bushings to reduce microphonics and other vibration difficulties. In order to get the high counting rate required to minimize statistical fluctuations, the time constant of the G-M tube recharging circuit was made as low as possible. Four megohms was the lowest series resistance that could be used between the high voltage and the G-M anode and still have a satisfactory plateau on the curve of counting rate versus anode voltage.

The quenching and first amplifier tube was chosen to have low capacitances in parallel with the G-M tubes. An 832-A double pentode was used for this reason, and also because of its higher voltage rating than conventional receiving-type tubes. The amplifier tubes were miniatures in order to conserve space, and 6C4 cathode followers were used to drive the long signal cables.

The rate meter circuit is shown in Fig. 3. The positive pulses from the two cathode followers are added at the grid of the 6AK5, clipped, amplified further, inverted by the 6C4, and sharpened and clipped as positive pulses at the grid of the 6AG7 frequency-meter tube. This tube is driven from cutoff to saturation by each pulse. A series grid resistor is used so that saturation current is approximately the same regardless of the amplitude of the input pulses. Each pulse changes the voltage across a precision capacitor in the plate circuit by a known amount.

The capacitor discharge current flows through the 6H6 and is stored by the 4-μf capacitor. Since this capacitor has a fixed impedance drain, the current through the impedance and the voltage across the capacitor are both proportional to the average frequency of the pulses. This is measured by a rate meter calibrated in counts per second. A gang switch provides full-scale readings of 1, 2, 5, 10, 20, and 50 kc.

A second circuit contains a meter with a linear scale covering +60 to −50 percent error and a logarithmic scale from +2 to −2 mils thickness deviation. This carries current not only from the rate meter, but also from a balancing circuit which supplies constant current of such a magnitude that the resultant through the meter is normally zero with a sheet of the correct thickness.

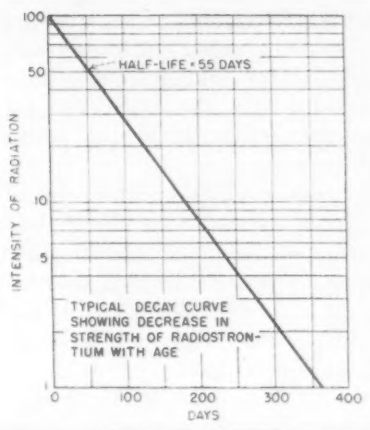
Both the balancing current and the rate meter are supplied from the same regulated source, so that changes in this 290-volt supply have no effect on the deviation meter.

Diode current in the 6H6 in the absence of a signal is prevented by a 1.1-volt bias developed across the

Table I—Beta-Ray Sources Having Long Half-Life and High Energy

Element	Mev*	Half Life
$_{6}C^{14}$	0.09	10^{4} years
$_{15}P^{32}$	1.69	14.3 day gamma-free
$_{16}S^{35}$	0.12	88 days
$_{37}Rb^{86}$	1.60	19.5 days
$_{37}Rb^{87}$	0.13	6×10^{10} years
$_{38}Sr^{89}$	1.32	55 days gamma-free
$_{40}Zr^{93}$	about 0.25	63 days
$_{41}Cb^{92}$	1.38	11 days
$_{71}Lu^{176}$	0.22	7×10^{10} years
$_{72}Hf^{181}$	....	55 days
$_{73}Ta^{182}$	....	97 days
$_{77}Ir^{192,194}$	....	60 days
$_{82}RaD^{210}$	0.025	22.2 years

*Million electron volts.



190-ohm voltage-divider resistor. The calibration of the frequency meter is independent of the characteristics of the 6AG7 tube, and is a function only of the magnitude of the plate voltage supply.

Voltage Supplies

Power supply circuits used for the beta-ray thickness gage are shown in Fig. 4. Conventional full-wave and half-wave circuits with VR tubes across the outputs provide +300, +150 and −105 volts. The G-M tubes require well-regulated voltage sources, however, as shown at the lower left in Fig. 4. A neon glow tube reference has better regulation than a VR tube, hence four type 991 neon tubes are used; these must be selected and pre-aged carefully. All of the first amplifier tubes in the voltage regulator circuits are operated at very low currents so that the total change in current through the 991 tubes is about one ma, which is the maximum permissible current change for satisfactory operation. The neon tubes also regulate the +290-volt supply for the frequency-meter tube and the balancing circuit.

The screen grid of the 6SJ7 is supplied from an unregulated source in order to compensate partially for changes in the a-c line voltage. The fine calibration of the frequency meter was adjusted by varying the 290-volt regulated supply with the grid potentiometer for the 6SJ7 tube.

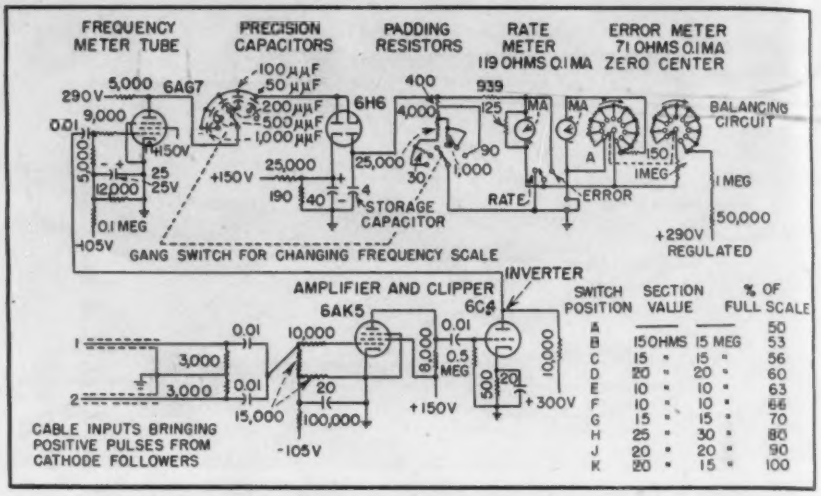


FIG. 3—Measuring circuits of the beta-ray thickness gage

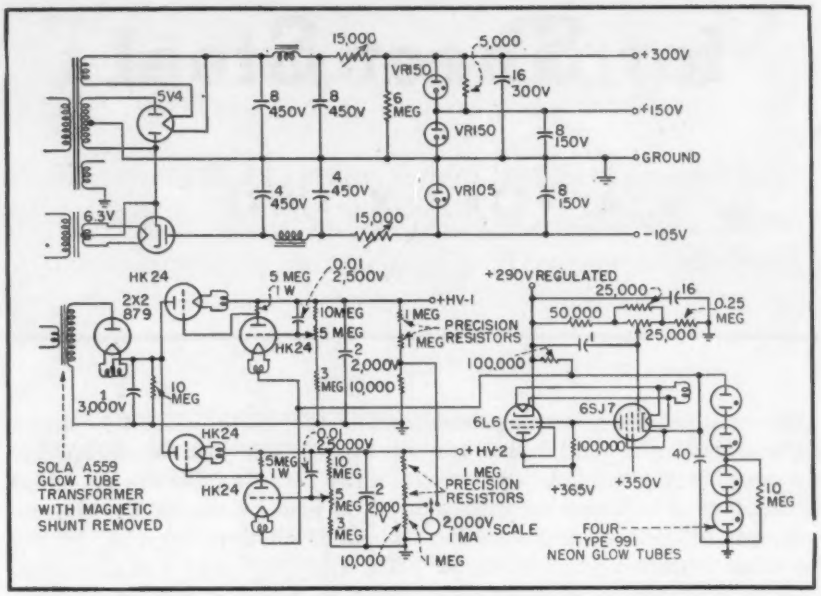


FIG. 4—Low-voltage supply and regulated power supply for thickness gage

Rate Meter

Since this pulse counter is designed to measure the average frequency of randomly distributed pulses, the resolving time of the 6AG7 counting tube must be very short with reference to the average time between pulses. This was accomplished by making the time constants low for the charging and discharging circuits of the precision capacitors.

Figure 5 shows the calibration of the frequency meter for pulses with uniform spacing. It can be seen that the response dropped to 92.6 percent of what it should be at ten times full-scale frequency, on each scale except 50 kc.

The response drop of Fig. 5 may be approximately analyzed by using a universal pulse response curve for an RC circuit, one form of which is plotted in Fig. 6A. This shows the decrease in output as the pulse length becomes shorter, the time between pulses being very long. The condition holds for all cases where the response is limited by the time constant of the circuit carrying current during the pulse.

Figure 6B is a universal pulse response curve of an RC circuit when pulse length is fixed. It shows the decrease in output for increasing frequency with a fixed pulse length. This is valid only when the time constant is much less than the pulse length and the period is slightly more than the pulse length. It holds for all cases where the response is limited by the time constant of the circuit carrying current between the pulses, such as two pulses occurring close together in a random distribution. The generalized time scale is the ratio of the difference between the pulse length and the period to the time constant.

Figure 6C shows the form of the resolution curve for the equipment for uniform input frequencies. The lower universal curve is the same as in Fig. 6A, and f_m/f is the ratio of the frequency meter response to the actual frequency as given in Fig. 5. An increase in the average frequency increases the bias due to grid rectification in the pulse-shaping amplifiers and results in a de-

crease in the pulse length. This data was taken with the gang switch set at 10 kc.

The intervals in a Poisson distribution of pulses can be obtained from Fig. 7. For an average rate of F counts per second and a resolving interval of t seconds (no pulse being recorded after an interval shorter than t seconds), the per-unit error scale $(1-f/F)$ used with curve A shows the fraction of all intervals which are shorter than t seconds. This curve and scale also represent the fraction of intervals shorter than an arbitrary t in any Poisson distribution, irrespective of whether there exists an actual measuring device. The f/F scale with curve A gives the fraction of the intervals that are longer than t seconds.

The response f_m/f from Fig. 5 is entered in Fig. 6A, and the value of t/T determined. Then f is plotted versus t/T in Fig. 6C, to show the decrease in the pulse length. At low frequencies t/T becomes a maximum of about 14, and the pulse length t is a maximum of 2.2 microseconds. The pulse length does not vary in a random distribution, for it is a function only of the average rate. As long as the rate meter reads less than 10 kc, the pulse length, is greater than 1.4μ sec.

With the meter switch set at 10 kc and with an input of random pulses whose average is 10 kc, the meter will read slightly in error due to some of the pulses coming at very close intervals. Those pulses separated by a spacing less than the pulse length of 1.4 microseconds will not count at all; $Ft=0.014$ and per-unit lost pulses=0.014. Figure 6B holds in this case, because the pulse length is constant as long as the average frequency is constant. Each pulse will count for only half a pulse if it follows an interval that makes $(1/f-t)/T=0.7$. Since $T=0.16$ microsecond and $t=1.4$ microseconds, this makes $1/f=1.5$ microseconds, $Ft=0.015$, and only $0.015-0.014=0.001$ per-unit pulses count between zero and one-half.

Again referring to Fig. 6B, each pulse will count for 0.99 of a pulse that follows an interval for which $1/f=2.14$ microseconds, $Ft=0.0214$, and only $0.0214-0.015=0.0064$ per-unit pulses count for less than 0.99 pulse and more than 0.5 pulse.

Summing these effects, effectively only 0.0146 per-unit pulses are lost due to the finite resolving time of the meter, with a random input. This 1.5-percent error corresponds to a rate of 10 kc and is considerably less for lower frequencies.

In addition to the uniform frequency meter scale, one could use a second meter scale on which the spacing of the divisions compensated for this error, or a calibration curve could be plotted. (This error in the rate meter must not be confused with that due to the resolving time of the Geiger-counter tube itself, which is of a different kind.)

Calibration of Thickness Meter

The time constants of the electrical circuits for the rate meter and the thickness meter are long with respect to 0.1 second. It was desirable for the thickness meter to average over an interval of about ½ second. The electromechanical system of a 100-microampere, 71-ohm, 3-inch panel meter had an apparent time constant of ½ second when a total equivalent shunting resistance of 400 ohms was presented to the meter.

The circuit actually used for the thickness meter consists of a 300-ohm tapped shunt in parallel with this style of meter. The rate meter is a 119-ohm type, shunted with 125 ohms. The 939-ohm resistance in series with this meter performs two functions. It makes the padding resistors large, so that small resistance changes in the meter and relaying circuits do not affect the calibration. Conversely, changes in the padding resistors with changing scale settings do not alter the time constants of the meters.

The zero reading on the thickness meter can be adjusted, regardless of the rate meter reading, by varying the compensating current with the one-megohm variable resistance shown in Fig. 3.

A given angular deflection of the thickness meter represents a fixed percentage change in the rate. Therefore, the calibration of the thickness meter must be a function of the rate meter reading, and inversely proportional to it. This change in calibration is effected by a tap on the error meter shunt, which varies the distribution of current between the meter and the shunt without varying the impedance presented to the meter by the shunt.

The taps were computed so that a change in the rate-meter current of 50 percent corresponds to a change of 50 microamperes in the error meter, or half scale. The error meter is provided with a zero-center linear percentage scale from +60 percent for a negative current of 60 microamperes to −50 percent for a positive current of 50 microamperes through the meter. There is also a logarithmic thickness scale for mils of iron.

It is possible to correct for apparent thickness errors due to either the resolving time of the G-M tubes or the use of a strontium instead of a phosphorus source. The correction is made by changing the setting on the tapped switch. If the thickness meter reads only 0.8 of the actual thickness change, then the tapped switch is set to 0.8 of the actual rate, and the thickness gage re-zeroed with the continuously variable potentiometer.

Resolving Time and Dead Time

There are two common types of equipment to which a resolving

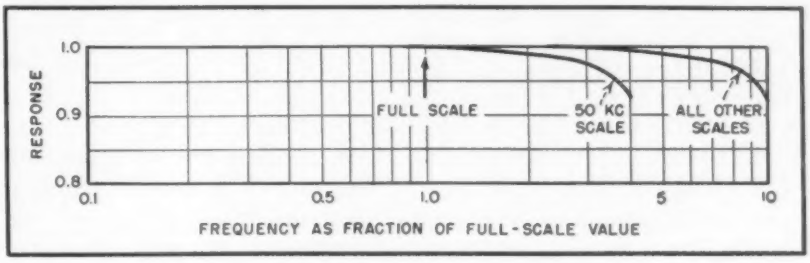


FIG. 5—Frequency-meter calibration for uniformly spaced pulses. Ordinate is response as fraction of what it should be

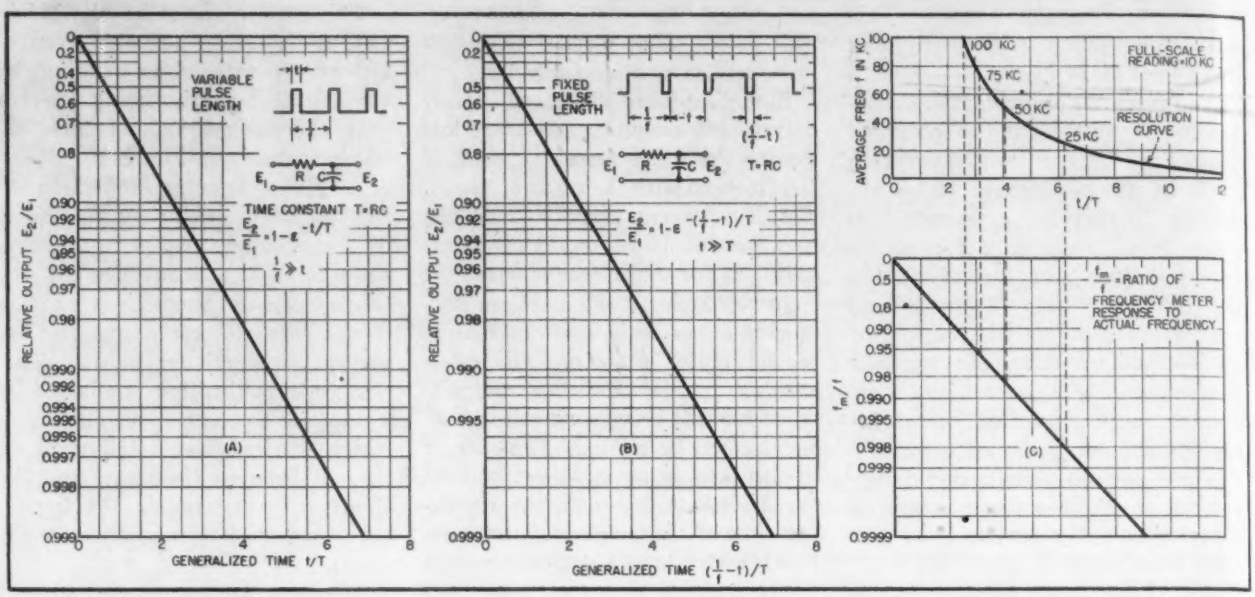


FIG. 8—Universal response curves for RC circuits with variable-length and fixed-length pulses, and resolution curve for the equipment

time has been ascribed. The first is called a type I recorder. In mechanical form, it is a pulse counter with a rachet mechanism. To be recorded, a count must be preceded by an interval t (resolving time) during which no count has arrived. This is the time required for the rachet mechanism to slide over a new tooth and engage its corner. If a number of counts arrive during this time, the corner will never be engaged, and no count will be recorded.

If a uniform input frequency to this counter is slowly increased, using uniformly spaced input pulses, the counter will reach a maximum and then jam, as shown by curve C in Fig. 7.

If the input to the counter is a Poisson distribution of average rate F, the counting rate will equal $f=Fe^{-Ft}$. The measured frequency f will reach a maximum rate of F/e when $Ft=1$, and then decrease. This is shown by curve B in Fig. 7, where the generalized reading ft of the frequency meter is plotted against the generalized actual input frequency Ft of random pulses. The value f is the frequency reading of a type I meter with a resolving time of t seconds.

For computing an actual Poisson distribution it is often convenient to have a correction factor, as a function of the measured rate instead of the actual rate, to apply to the measured rate. This has been plotted in Fig. 8A. It can be seen that $K=e$ for the above-mentioned maximum condition of $ft=1/e$ and $Ft=1$.

The resolving time of a type I device can be measured by supplying a uniform input frequency to it. The resolving time is equal to the reciprocal of the maximum frequency at which the device will operate. If a pure random distribution is supplied, the resolving time will be equal to the reciprocal of the input frequency F when the measured frequency f is a maximum: $t=1/F_t=1/ef_m$.

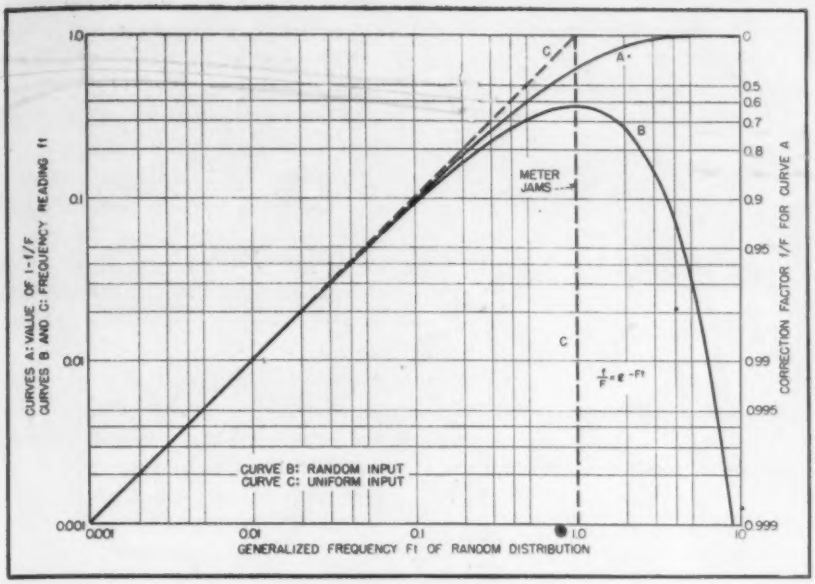
Sometimes it is desired to compute the resolving time from measurements made at much lower rates. The output frequencies of the device should be measured for two inputs whose ratio is exactly two. This can be done by accurately changing the position of a radioactive source from which the random pulses are derived. Then

$$f_1 = F_1 e^{-F_1 t}$$
$$f_2 = F_2 e^{-F_2 t}$$
$$F_2 = 2F_1$$
$$t = f_2/2f_1^2 \log_e (2f_1/f_2).$$

The second kind of device which has a resolving time is called a type II recorder. The recorder has a mechanism such that the recovery time is completely unaffected by additional counts coming in during the recovery period. This can be represented physically by a biased flip-flop pulse generator operated from negative signals. During the pulse which follows a signal, successive signals have no effect. The length of the pulse, t, is called the dead time, to distinguish it from the resolving time of a type I unit.

If the average frequency of a random distribution of input pulses to this device is slowly increased, the output frequency will reach a maximum asymptotically, and will not decrease at very high input rates. The output frequency measured on the device will be $f=F/(1+Ft)$. This reaches a maximum value of $1/t$, as shown in Fig. 8B. The correction factor to apply to the measured frequency is $K=(1+Ft)=1/(1-ft)$. This is plotted in Fig. 8C, for high counting rates. For low counting rates, the correction factor is approximately $(1+ft)$, or the error in the measured rate is f^2t.

If the input to this device is a uniform frequency, the output will equal the input until the maximum rate of response is reached, then the output will drop to one-half. As the input frequency rises from $1/t$ to $2/t$, the output again increases to its maximum value, and then drops to two-thirds. This is dotted curve B in Fig. 8B. The response will vary between the maximum


CURVES A: VALUE OF 1-1/F
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CORRECTION FACTOR 1/F FOR CURVE A
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FIG. 7—Poisson distribution of pulses

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$$f_1 = F_1/(1 + F_1 t)$$
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$$F_3 = 2F_1$$
$$t = 2/f_2 - 1/f_1$$

Geiger-Counter Tubes

The Geiger-counter tubes used in the thickness gage operate as type II devices at high counting rates. An ionizing event in the tube caused a small discharge, and a definite dead time had to elapse before the central electrode voltage had risen enough so that another ionizing event would cause a second cumulative discharge. Beta rays that entered the tube while the voltage was low operated as ionizing events but the rise of ionization was not cumulative, and therefore these beta rays represented lost counts. These counters had a maximum asymptotic rate of 16,000 cps as used in the thickness gage circuit. This represented a dead time of 60 microseconds.

There was another serious disadvantage of this dead time. The change of counting rate with change of beta-ray intensity was less at the higher counting rates, and became zero at 16,000 cps. A low counting rate gave the best resolution for thickness changes, but a high counting rate was needed to minimize the statistical fluctuations for rapid readings. The effectiveness of a G-M tube can be taken as the product of its ability to resolve thickness changes and its accuracy.

The per-unit fluctuation in a single reading of N counts is $N^{-0.5}$ for a true Poisson distribution. The per-unit (fractional) probable error of a rate meter reading of time constant T with n G-M tubes each receiving F random counts per second is $(2nFt)^{-0.5}$.

Curve A in Fig. 8B is $ft = Ft/(1 + Ft)$. Thickness change resolution is proportional to its slope: $df/dF = 1/(1 + Ft)^2$. The effectiveness product would be $P = (2nFt)^{0.5}/(1 + Ft)^2$. This product is a maximum when $dp/dF = 0$. Then $Ft = 1/3$. From Fig. 8B, $ft = 1/4$ and $f = 1/4t = 16{,}000/4 = 4{,}000$ cps reading, per tube. Nothing is gained in exceeding this rate, for the G-M tubes are more stable at lower counting rates.

Gaging Sheet Steel

One application of a thickness gage of this sort is in a tin plate mill, where steel sheets range in thickness from 7 mils to 24 mils. These sheets can be measured by the beta-ray thickness gage as they move on the shearing line. After being cut into lengths, the sheets can be sorted by a mechanical gate (controlled by the measuring device) into on-gage and off-gage sheets. The switches on the thickness meter control a memory device on the mechanical gate, which takes care of the time lag necessary due

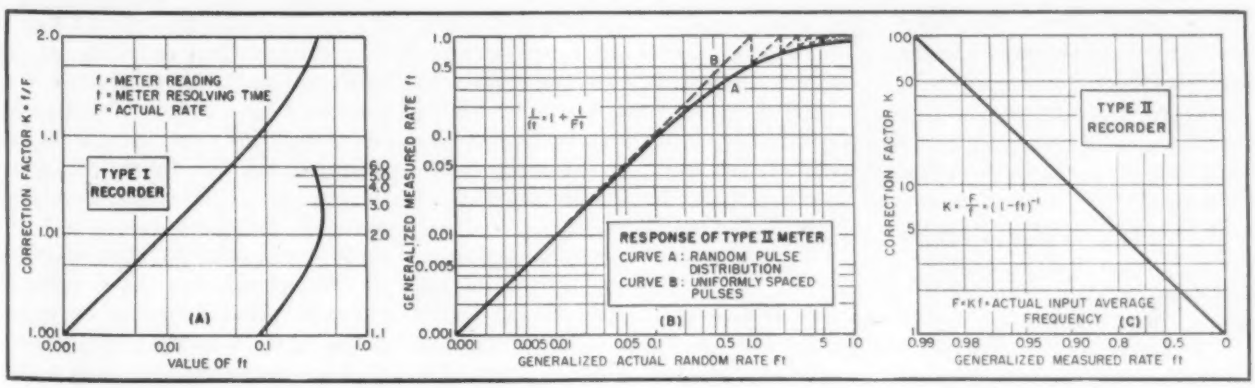

FIG. 8—Correction-factor curves for type I and type II recorders, and response of type II meter to Poisson distribution of pulses

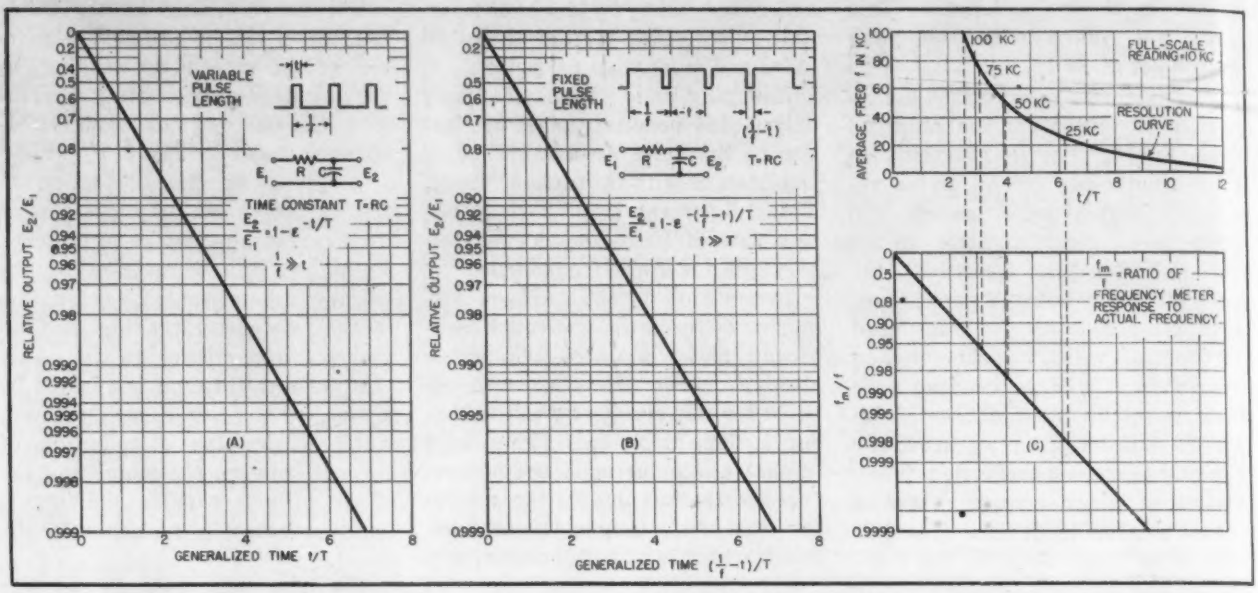

FIG. 6—Universal response curves for RC circuits with variable-length and fixed-length pulses, and resolution curve for the equipment

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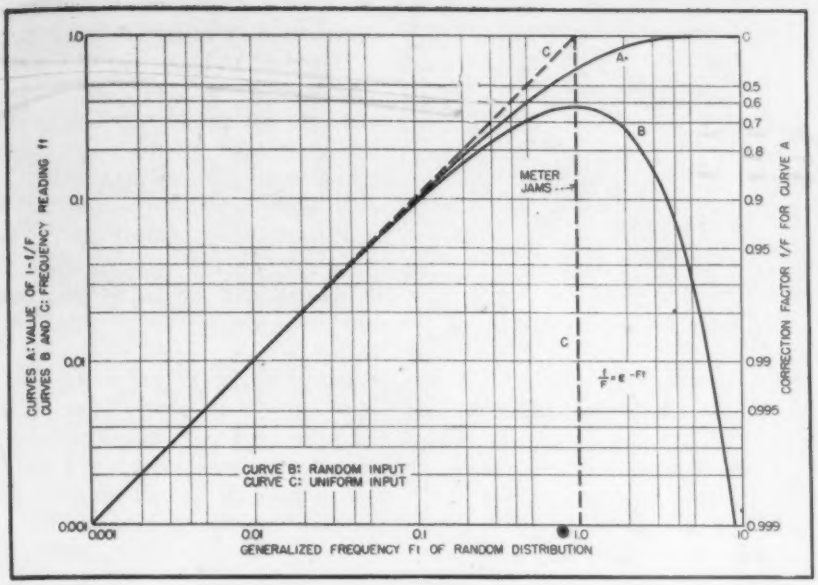
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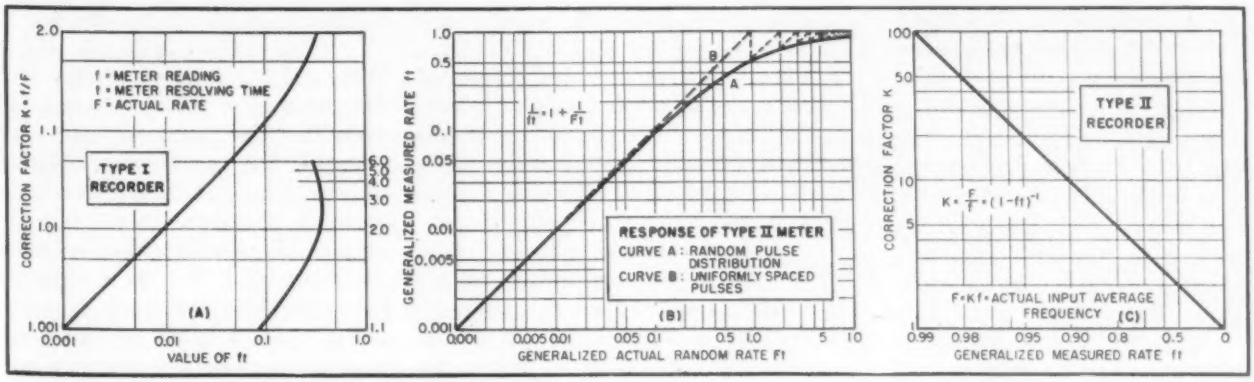


FIG. 8—Correction-factor curves for type I and type II recorders, and response of type II meter to Poisson distribution of pulses

to the physical displacement between the flying micrometer and the gate.

Continuous-Reading Meter

The maximum error in any continuous measurement of this sort can be estimated. Figure 9 shows the electrical equivalent circuit of the indicating meter, where input voltage X and output voltage Y correspond to the actual thickness and the measured thickness respectively. The response of this circuit is

$$\begin{aligned} X &= iR + Y \\ X &= iR + (1/Cp)i \\ CpX &= RCpi + i = Tpi + i \\ i &= CpX/(1 + Tp) \end{aligned}$$

Here $T = RC$ is the time constant of the measuring circuit or meter.

When X has been changing steadily in the same direction for a long time, and there is no second derivative of either X or Y with respect to time, $dX/dt = dY/dt$, $i = C\,dY/dt = C\,dX/dt$, and $X = Y + iR = Y + T\,dX/dt$. The maximum error in the measurement of X is $(T\,dx/dt)$.

If we assume that a constant thickness of sheet is coming through the micrometer, and that at time $t = 0$ the thickness began to increase at a constant rate of $dx/dt = R_1$, the solution would be

$$i = Ke^{-t/T} + C\,dX/dt$$

When $t = 0$, $i = 0$, error $= 0$, and

$$\begin{aligned} K &= -CR_1 \\ i &= CR_1(1 - e^{-t/T}) \\ Y &= X - RCR_1(1 - e^{-t/T}) \\ \text{Error} &= X - Y = TR_1(1 - e^{-t/T}) \end{aligned}$$

After a long time, the steady-state value of Y is $Y = X - R_1T$, and maximum error $= R_1T$.

The curve of thickness X in Fig. 9 also shows a sharp bump on the sheet. Considering zero time at the peak of the bump, there is a steady rate of change of thickness $dX/dt = R_1$ before zero time, and a different rate of change R_2 (negative) afterwards.

$$i = Ke^{-t/T} + C\,dX/dt_{\,t>0}$$

When t is 0, $i = (X-Y)/R = R_1T/R = K + CR_2$, $K = C(R_1 - R_2)$, and

$$i = CR_2(1 - e^{-t/T}) + CR_1e^{-t/T}$$

Y is a maximum at time t_m when $dY/dt = 0$.

$$\begin{aligned} Y &= X - iR = X_0 + R_2t - \\ &\quad TR_2(1 - e^{-t/T}) - TR_1e^{-t/T} \\ dY/dt &= R_2(1 - e^{-t/T}) + R_1e^{-t/T} \\ t_m/T &= \ln(R_2 - R_1)/R_2 \end{aligned}$$

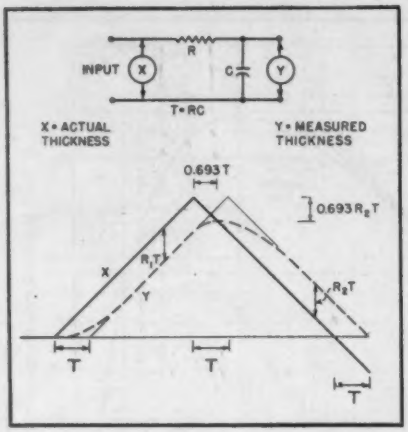


FIG. 9—Time response and equivalent electrical circuit of indicating meter

This is also the time at which the error is zero and the dotted Y curve crosses the solid X curve, for when $i = 0$,

$$\begin{aligned} R_2(1 - e^{-t/T}) &= -R_1e^{-t/T} \\ t/T &= \ln(R_2 - R_1)/R_2 \end{aligned}$$

If $R_2 = -R_1$, $t_m = 0.693\,T$. At this instant, the meter has its maximum deflection, and is in error from the maximum height of the bump by $0.693\,R_2T$. The error reaches its maximum practical value when the rate of thickness change has been constant in the same direction for considerably longer than the meter time constant. This is again the value R_2T. The maximum error in the time position of a sharp bump is thus $0.693\,T$ where T is the time constant of the measuring system, and the maximum error in the height of a sharp bump is $0.693\,R_mT$ where $R_m = dX/dt$.

Proposed Systems

An optimum in operation is obtained if the setting of a sorting or reject gate considers the fact that the meter reading most closely approximates the thickness of the sheet passing through a short time before. A sheet that registers on-gage, following one that registered off-gage, is always a good sheet. Therefore, for conservative operation, the reject gate may be set to discard the sheet preceding as well as an indicated bad sheet.

In an acceptable thickness gage, the meter reading should be assumed to correspond to the thickness at a time $0.7\,T$ preceding. This gives the error in height for sharp bumps as $0.7\,R_mT$, and the error for a steady rate of change of thickness R_m would be only $0.3\,R_mT$.

The speed of operation of a thickness gage is an important factor. The beta-ray gage is limited by the time constant of the integrating rate meter. If this time constant is short to make the speed of operation fast, then the statistical errors will be large. As the time constant is increased, both the statistical errors and the speed of operation will decrease.

In designing a gage, the maximum statistical error (three times the probable error) should be made equal to the maximum speed error, and each equal to half of the total permissible error E in mils.

$$\begin{aligned} E/2 &= 3 \times 2.94/\sqrt{2nFT} = 0.7\,R_mT \\ T &= E/1.4\,R_m \\ (nF)_{min} &= 25.2\,(2.94)^2\,R_m/E^3 \end{aligned}$$

Design values of total error E and maximum rate of thickness change R_m can be entered in this equation, and minimum values of total random counts per second, $(nF)_{min}$, can be computed.

The total thickness change which it is desired to measure determines the maximum counting rate, and influences the number of tubes required. The value of $(nF)_{min}$ given above occurs at maximum thickness. If the minimum thickness is d mils less than the maximum,

$$(nF)_{max} = (nF)_{min}e^{0.346\,d}$$

For a G-M dead time t, the maximum-effectiveness product occurs at a rate $F = 1/3t$. It is not good practice to operate the G-M tubes at a rate much higher than this, and therefore $F_{max} = 1/3t$. The number of tubes required is

$$n = 654\,R_m t\,e^{0.346\,d}/E^3$$

If R_m is 0.2 mil per second, t is 60 microseconds, d is 0.2 mil, and the maximum permissible error is 0.2 mil, $T = 0.7$ second, and $n = 1$. One tube is thus required. If the measurable thickness change d is increased by a factor of ten to 2.0 mils, the time constant will be unchanged, but two tubes will be required. If, further, the maximum error is decreased to 0.1 mil, the meter time constant must be halved to 0.35 second, and the number of tubes required increased by a factor of 8, to 16 total. It can be seen that the permissible error is a very critical design factor.

Radar-equipped, the Standard Oil towboat SOHIO SOUTHERN, pushes 12 barges containing 15,750 tons crude oil and four empty barges up the Ohio River

Peacetime RADAR

Towboat traffic on narrow inland waterways is expedited by radar equipment. Saving as much as $100 an hour when ships are stalled in fog, use of electronic units permits continuous movement of boats and barges in conditions of zero visibility

By B. B. TALLEY
Colonel, Corps of Engineers
District Engineer, Louisville District
Corps of Engineers, USA

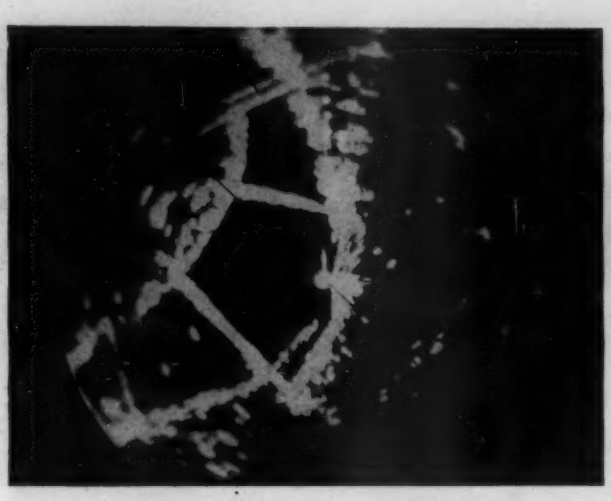
FOG has always been the enemy of commerce on the Ohio River and many other inland streams of the country. At some seasons of the year it persists during the early hours of almost every day. Mixed with smoke from the factories of cities it is doubly prevalent in the vicinity of the numerous highly industrialized areas.

Large towboats often push tows of 20,000 deadweight tons and some of these and other boats on the Ohio and Mississippi cost as much as $100 per hour to operate. Until the advent of radar they were forced to tie to the riverbank in time of fog, with a resultant slowdown of movement, increased cost of operation, and obviously, at an increased cost to the consumer of the goods being transported.

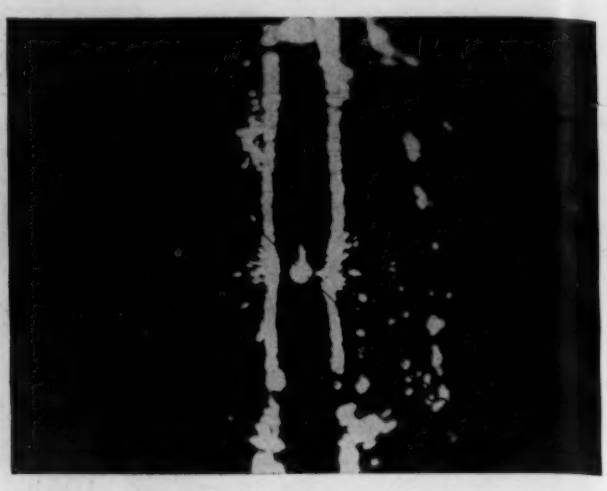
As a means of permitting continuous movement of traffic on inland waterways regardless of weather, the Louisville District, Corps of Engineers, in May, 1946, undertook the development of radar and radar navigation charts for the Ohio River. Private navigation interests, notably the Ashland Oil & Refining Company, have equipped some of their boats with radar for experimental purposes with noteworthy results and the U. S. Coast Guard has installed a three-centimeter radar aboard its cutter SUMAC.

Survey Equipment

In March 1947, the Louisville District installed a Radiomarine Corporation model CR 101 radar on the survey boat CHEROKEE, a converted sea-air rescue boat. The equipment incorporates many of the latest advances in the radar field, providing optimum performance at ranges of 1½ and 5 miles, with appropriate range-rings for all ranges to 50 miles. It radiates a 1.6-degree horizontal beam on a 17-degree vertical pattern, using a super high frequency of 9,320-9,500 megacycles, and magnetron center



Pilot's radar view of bridges and locks as the SOHIO SOUTHERN leaves the canal at Louisville. The white circle at center is the boat and the projection upward is the line of barges

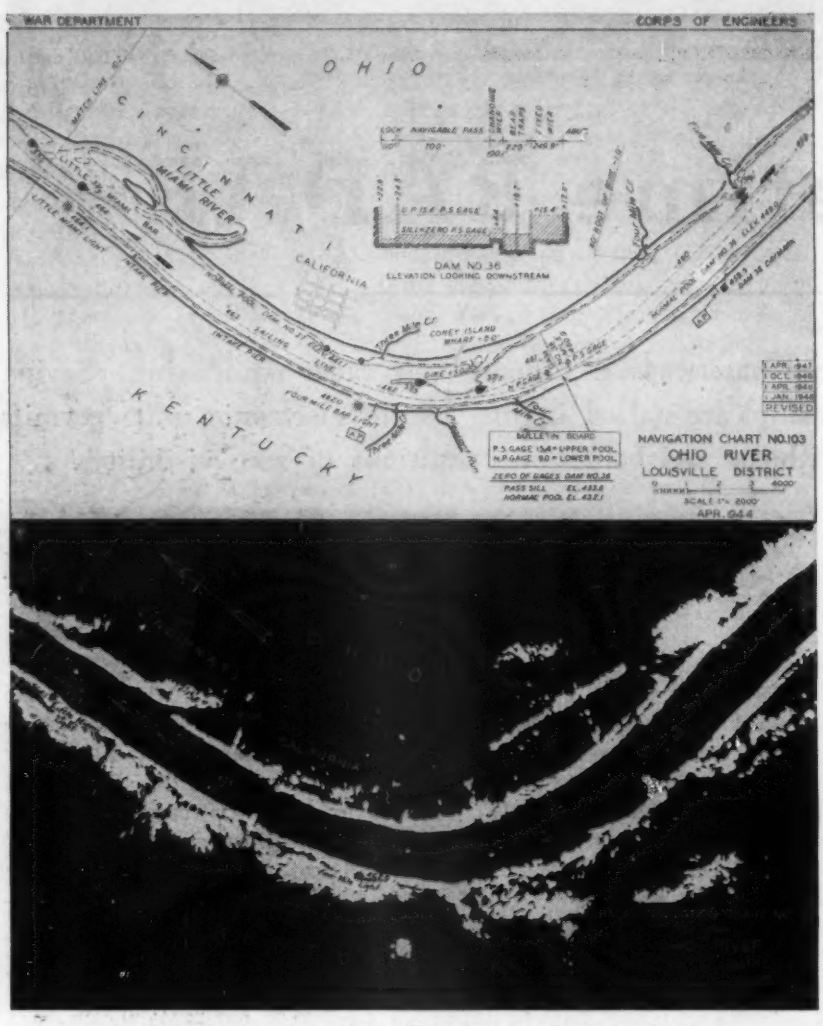


Now in midstream, the ship and its tow passes the intake works of the Louisville municipal water system. The white spot in the channel at the top of the photo is an oncoming boat

frequency of 9,375 megacycles, 3.2-centimeter wavelength.

The unit gives good range-resolution with a minimum range of 80 yards. It is presently powered from a 5-kw, 4-cylinder, 60-cycle a-c auxiliary generator set, and draws approximately 12 amperes at an input voltage of 117.

Objects as close as 80 yards are reproduced on a ppi scope and materially assist in navigating narrow river-channels and approaches to locks and dams. The antenna revolves at 12 rpm through a 360-degree path, thus scanning the horizon once each five seconds. Inasmuch as the cathode-ray tube has a persistence of image of about 30 seconds, a continuous image remains on the screen.



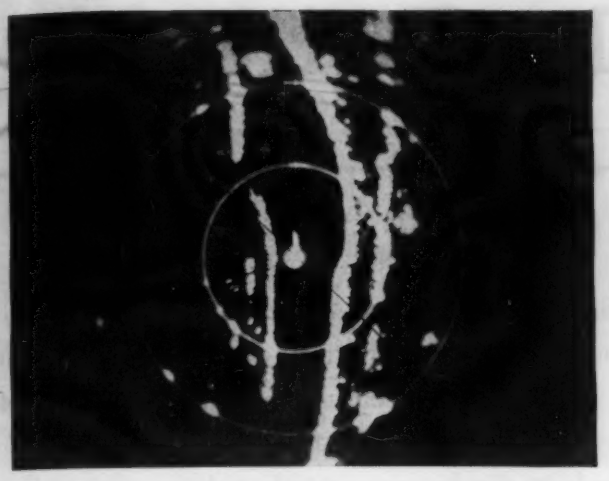
A conventional navigation chart of the Ohio River at Cincinnati is shown at top. Below it is a controlled mosaic formed by matching several photographs of radar images taken at several points, and rephotographing. With the new chart, pilot of radar-equipped boat can follow the channel or sailing line in fog or darkness

Continuous Chart

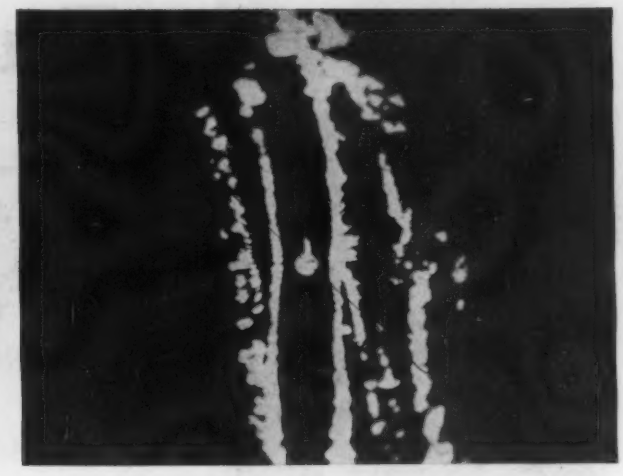
A series of overlapping or contiguous photographs of the screen made as the boat progresses along a given line (the sailing line of a channel) can be combined into a controlled mosaic to form a continuous strip map or chart. A 4 x 5 Graflex camera is fitted to the radar, mounted in a metal hood and at a fixed focal length from and parallel to the plane of the screen.

This arrangement was satisfactory for experimental purposes and with certain refinements, including the introduction of an automatic shutter-operation, might prove an acceptable method of conducting an ultimate program of chart making. Concurrent experiments are underway, with an automatic radar recording camera built for strictly military purposes during the war by the Fairchild Camera and Instrument Corporation.

To obtain photographs with the



Distance rings one-half mile apart show an approaching boat as a little more than a mile away. The ship is now following the sailing line off Six Mile Island above Louisville



Clear sailing ahead after passing bridges and other obstructions at Louisville. Unhampered by fog or night, the pilot can match the scope screen against the radar navigation chart

Fairchild camera, it is necessary only to mount it on the radar, set the intervalometer at the desired interval, and turn on the switch. The camera is interconnected with the electrical circuit of the radar and operates with manual attention only to the intervalometer.

Because of persistence of image on the ppi scope, the image obtained by one sweep of the antenna cannot be erased before the next one commences to be formed. Thus, there are 2 to 3 overlapping images of different degrees of brilliance on the scope at all times. This causes a blurred picture when photographed. To eliminate this overlapping and to increase definition of image, the cathode-ray tube is energized only during periods of photography. This is done automatically by a relay in the electrical circuit of the radar and camera.

The camera magazine has a capacity of 1,600 exposures, and one loading of the camera is sufficient to photograph more than 100 miles of river.

Beacons Needed

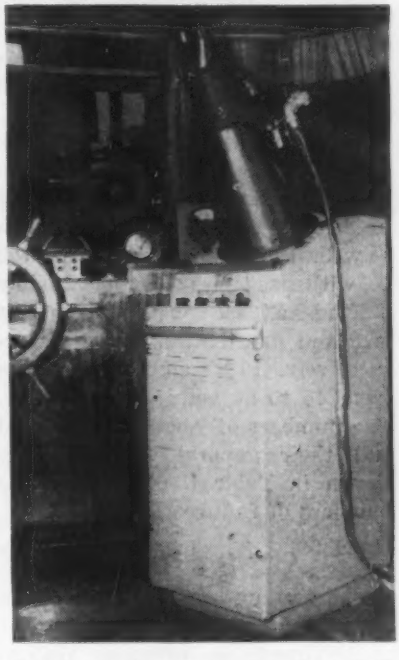
One shortcoming of radar has been its failure to resolve into easily identifiable form the individual piers and spans of a bridge. As they appear on provisional radar navigation charts the images of bridges are solid white (blank) walls across the stream. Although the sailing line has been transcribed from conventional navigation charts in its correct position on the radar charts, a pilot would be running some risk should he attempt to navigate within a narrow channel under a bridge with only the location of his sailing line shown on his chart.

It is necessary for him to judge his distance from shore and estimate the location of the bridge piers. This situation can be corrected by placing buoys or channel markers above and below the bridge to mark the navigable span to be picked up by radar when they are one half to one mile distant. There are objections to placing these buoys in the river, however, as they would become possible obstructions to navigation, or at least tend to confuse the pilots of craft not equipped with radar.

The solution may lie in the field of small, economically-built low-power automatic transponder radars, or the perfection of a suitable metal target easily and cheaply installed and requiring a minimum of maintenance attention. The coded transponder is a form of automatic radar transmitter that sends out interrupted signals in a predetermined code. This positive signal is stronger than the echo signals to the master radar and it shows with greater brightness on the cathode-ray tube screen than those reflected from surrounding objects.

The best known of these coded instruments is the Army Air Force's iff system (Identification Friend or Foe). The Air Material Technical Command at Wright Field is cooperating in the studies. A conception of the result desired is shown in the accompanying illustrations.

The present radar navigation chart requires use of illumination at night. This is objectionable to pilots, accustomed to working in the dark. The objection may be overcome, either by means of transparent radar charts to be viewed on a light table, or by printing the charts with fluorescent ink which will glow under ultraviolet light—the latter has been done simply and effectively.



Radar console in the survey boat CHEROKEE. Attached to the light shield is the automatic recording camera

Tube Failures

Blistered cathodes of 6SN7 tube after blisters have broken away

Analysis of causes of tube failures in 18,800-tube electronic computing machine during one year of operation shows that open heaters and damaged cathode coatings are chief troubles. An average of two tubes failed each time the a-c supply to the heaters was shut down

By F. ROBERT MICHAEL

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The Electronic Numerical Integrator and Computor (ENIAC) provides, after a year of operation, unique life test information in the failures among its 18,800 vacuum tubes and their chronological occurrence during that year. All tubes which failed were opened and examined with a binocular microscope, and all noticeable defects were classified and recorded. The various faults which caused tube failure are illustrated and discussed here, and in several cases their rate of occurrence is plotted against time.

In the ENIAC, numbers are represented by combinations of electrical pulses, and the pulse system is used for the transmission of orders as well. Pulse repetition rate is 100 kc, with rise times of approximately 0.2 and 0.5 μ sec for pulse durations of 2 and greater than 10 μ sec respectively. Pulse amplitudes range from 15 to 50 volts in most cases. The numbers of vacuum tubes used and their general functions are shown in Table I, along with the numbers of failures for each type.

Operating Practices

The vacuum-tube heaters were in operation approximately 80 percent of the time from November 1945 to November 1946, amounting to 7,000 hours. Heater circuits were turned off at night for the first few months, and during this period a comparatively large number of tube failures resulted from heater-to-cathode shorts. It was felt that these failures might be due to initial current surges in the a-c circuit. Investigation showed the transient current to be approximately four times steady state, which agrees well with the hot-to-cold resistance ratio of tungsten heaters at 1,000 to 1,200 degrees K.

It was necessary at that time to allow any corrective circuit change to wait until the scheduled moving of the ENIAC to Aberdeen, Maryland, and to leave the heater circuits on 24 hours a day with the exception of accidental power failures. The rate of failure for a-c shut downs averaged about two tube failures out of 18,800 per heater shut down, which was a small rate but undesirable because of the time required to locate and replace failures.

Meanwhile a series of experiments was started, using 100 tube samples, to determine whether a graduated application of voltage would materially reduce the rate of failure caused when heaters were turned off and on. Such experiments showed no difference between the group of tubes to which full voltage was applied at once and those receiving a gradual application of voltage.

It was the practice to shut off the d-c supply each night and at any time the ENIAC was left unattended except when it was actually working on a problem. No correlation between d-c supply voltage shut downs and tube failure rate was noticed.

Design Center Values

Tube life and probability for failure are important considerations when a large number of vacuum tubes is involved; especially when, because of ENIAC's high speed, so much possible work is lost in breakdown time. Design center values were therefore chosen conservatively.

Heater voltages were designed for 95 percent of rated voltage or 6.0 volts $\pm$ 0.1, although they aver-

INDUSTRIAL SIGNIFICANCE

Reduction of tube failures is even more important in industrial electronic equipment than in ENIAC because trained troubleshooters are not always on hand in factories. Therefore, many of the conclusions presented here on selection and operation of standard tubes in the ENIAC can profitably be utilized to improve the odds against failure of tubes in industrial service

in ENIAC

aged about 5.9 volts. Grid current was limited to 1 ma, with 0.5 ma average current. Grids were swung negative three times the cutoff voltage, but not exceeding 150 volts negative to the cathode.

Plate voltage was set at 50 percent of maximum ccs (continuous commercial service) rating, plate current at 25 percent maximum ccs rating, screen voltage at 50 percent maximum ccs rating, and screen current at 25 percent maximum ccs rating.

Maximum heater-to-cathode potential was limited to ± 50 volts, with one side of all heaters tied to a d-c potential. Power supply voltages were bypassed to cut signal hash and a-c hum to 2 percent (peak to peak) of the d-c magnitude.

Standard commercial receiving tubes with octal bases were purchased throughout 1943 to 1945 from a number of manufacturers and were tested individually for acceptance before use in the ENIAC. Allowance was made for a ± 50 percent cutoff voltage variation and a ± 40 percent variation in r_p for all tubes with the exception of cutoff in 6AC7. This latter was held to a ± 0.5 volt tolerance. Approximately 5 percent of all tubes were rejected except 6AC7, in which case about 40 percent were rejected.

Tube Failure Records

It was evident that keeping a record of tube failures would allow anticipation of more troublesome periods in operation. Investigation of causes of failures gave information for possible circuit changes and tube specifications which would permit further reduction of breakdowns, increasing the reliability of operation. An attempt was made to open each tube that failed in a way that would not change the internal conditions at the time of failure.

Table I—Summary of Tube Failures in ENIAC

Type	Approx. Number of Tubes	Percent of 18,800	Number of Tubes Removed	Percent of 644 Tubes Removed	General Use
6SN7 Twin Triode	6,550	35.0	200	31.0	Trigger and pulse counting circuits; also normally-on amplifier
6L6 Beam Power	4,200	22.0	175	27.2	Pulse amplifier; transmission normally off, pulsed on
6SA7 Pentagrid Converter	2,600	14.1	50	7.8	Coincidence tube, normally off; turned on by pulsing both grids; called gate
6SJ7 Triple Grid Amplifier	1,500	8.0	20	3.1	Input pulse amplifier; normally off
6V6 Beam Power	1,300	7.0	25	3.9	Pulse-forming circuits; normally on, pulsed off
6L7 Pentagrid Mixer	1,200	6.5	35	5.4	Use similar to 6SA7
6AC7 Television Pentode	500	2.5	110	17.1	Normally on; input amplifier with critical cutoff
807 (Enlarged 6L6)	350	1.8	20	3.1	Power amplifier, high voltage swings; normally off
6J5 Detector Triode	300	1.6	2	0.3	Amplifier; normally on
6Y6 Beam Power	300	1.6	7	1.1	Amplifier; normally on
	18,800	100.0	644	100.0	

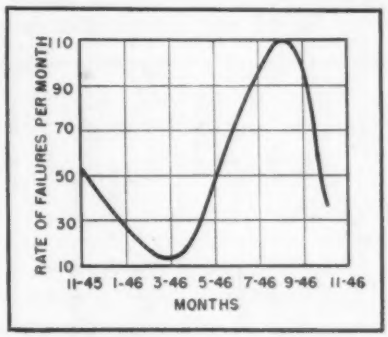

FIG. 1—Rate of failure of all tubes in one year of ENIAC operation

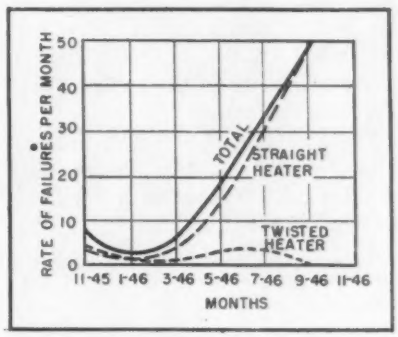

FIG. 2—Comparison of failures of straight and twisted heaters

Figure 1 provides a graphic record of tube failure per month for the 644 tubes removed from the ENIAC. The downward trend from November 1945 to March 1946 is probably marking the decreasing number of tubes at the borderline of acceptability when placed in operation in the ENIAC. This downward trend in rate of failure for the first 1,000 hours or so is normal experience when using large numbers of tubes. The peak in August 1946 is due largely to a complete overhaul given the machine in preparation for a problem which used its facilities to the utmost.

The five major causes of these 644 tube failures were: (1) open heater wire; (2) damaged oxide cathode coating; (3) internal leads and supports dangerously close; (4) open electrode spotwelds; (5) burned-open shorts. Open or damaged heaters accounted for 270 failures and damaged cathodes caused 150 failures, while the remaining three types of faults accounted for between 50 and 100 failures each.

Open Heater Wire

The 6SA7 tubes (14 percent of all tubes used in ENIAC) were con-

structed with the twisted type heater, and had no open-heater faults. The 6L6 tubes (22 percent) were constructed with straight or looped heaters and gave 15 percent of all open-heater failures. The 6SN7 tubes (35 percent) were constructed with both types of heaters, and contributed 75 percent of all open-heater failures, of which 15 percent were in twisted heaters and the remainder in straight heaters. The remaining 10 percent of open-heater failures came from tubes having straight heaters.

The fact that 57 percent of all tubes in the ENIAC produced 90 percent of the heater failures indicated possibilities of faults peculiar to these two types (6L6 and 6SN7). It was found that the straight folded-type heaters in these types, combined with certain manufacturing features, were mainly responsible for the failures.

In most of the open-heater faults of the twisted type, the heater wire had pulled away from the support wire. Such faults in both straight and twisted heaters seem to occur only when the spot weld between the heater and support wire has not imbedded the tungsten heater wire sufficiently in the softer metal (Ni alloy) support.

Examination of straight heaters showed approximately 90 percent of all faulty tubes with straight heaters either had the insulating coating chipped off their bends, baring the tungsten wire with additional circumferential cracks over its length, or appeared to have had their insulating coatings shifted away from the bend while in a semi-liquid state. The latter were probably coated by dipping, and tilted before they were dry. The first condition was the more prevalent. It is common practice in manufacturing to coat the tungsten wire by processing it while being wound from one spool onto another. The coated, spooled wire is then bent into the straight heater folds. In so bending, the coating cracks, baring some bends. A more elastic insulating coating is being sought by tube manufacturers.

Few twisted heaters showed chipped insulating coating and exposed bends. The 6L6 straight heaters gave most of their trouble in cathode-to-heater leaks. Figure 2 shows, for all tubes inspected, the rate of failures per month traceable to chipped or otherwise bared heater faults. Separate curves for twisted and straight-type heaters are included for comparison.

In an attempt to correlate a-c shutdowns with tube failures, a rack of 100 6L6 and 100 6SN7 tubes was tested by applying full heater voltage long enough for tubes to heat, and turning tubes off till cool, with this cycle being repeated continually. In the same rack another 100 6L6 and 100 6SN7 tubes were similarly cycled, but with heater voltage applied in steps to approximate a constant linear expansion in the heaters. This test showed little difference in tube failures between samples over a period of eight months.

One other fault noticed with heaters had to do with their mountings. Figure 3 shows the various types of heater mountings encountered in this investigation. In the case of single-heater tubes, the support wires are cut to the same length and bent into position. The heater wires should be run parallel far enough apart so that the supports do not touch, and close enough to slip easily into the cathode sleeve. Heaters were observed with the insulating coating worn away by rubbing of the cathode sleeve edge during vibration, expansion, and contraction. For this consideration the construction of Fig. 3A proves better than that of Fig. 3B.

If one support were cut shorter before bending, as in Fig. 3C, the supports could be closer without shorting, providing the heater wire is insulated down beyond the upper support. The heater would not then be spread, and chances of rubbing its insulating coating against the edge of the cathode sleeve would be minimized.

Of the two 6SN7 double mountings, that of Fig. 3E seemed to be the neater and less troublesome in this investigation. The upright posts in Fig. 3D provided more obstruction to the pliable cathode bands, causing the bands to short and burn open; actually, however, this mounting allows closer, more parallel heater wires to enter the cathode sleeve.

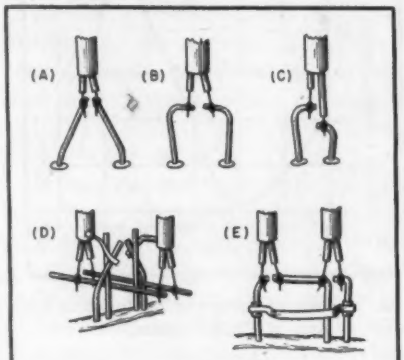

FIG. 3—Types of heater mountings encountered in ENIAC tubes

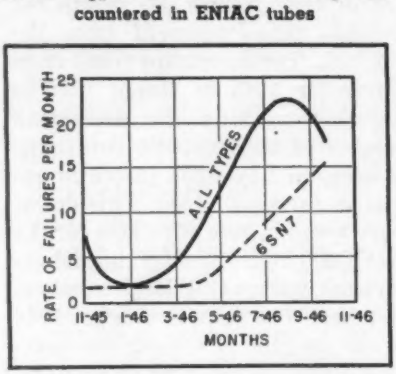

FIG. 4—Failures traceable to blistered oxide cathode coatings, causing low emission

Damaged Cathode Coating

With little exception, the main damage to cathode coatings was blistering—an uneven, bubble-like puff of oxide coating which when broken away exposes the bare cathode sleeve. Other damages, noted rarely, were burns or holes adjacent to shorted electrodes.

Rates of failures per month due to damaged oxide coatings are shown in Fig. 4 for all tubes and for 6SN7 tubes individually. The same tendency was noted for each other tube type. The curves turn upward in the vicinity of March, when the ENIAC was being used to capacity. The percentage increase in failures is many times greater than the approximate percentage of additional tubes used in March, which would indicate that blistering involves an aging effect.

As would be expected, most of the tubes with blistered cathodes were removed because of low emission. The most acceptable answer to blistering seems to be that of gas formation between sleeve and coating. This effect would increase with age if the following is assumed. Many

cylindrical cathode sleeves, such as 6SN7, are made with seams down their length. During processing, these sleeves are exposed to oil (or some other liquid) baths. If not thoroughly cleaned before the oxide coating is applied, the liquid, if thin enough, will infiltrate the seam and be covered with the oxide coating. In use, the heated liquid would diffuse through the coating along the surface of the cathode sleeve and liberate gas, causing blisters.

Internal Leads and Supports Dangerously Close

Support wires are considered to be those wires which leave the tube base pins to pass through the glass stem and press into the evacuated envelope. In some cases these support wires are bent and spot-welded directly onto the electrode structure. In other cases a thin, pliable copper or nickel band, here called a lead, is used to connect the support to the electrode structure.

The compromise necessary between the spread of the heater wires entering the cathode sleeve and the closeness of their supports can be responsible for shorted heaters.

The most dangerous of all near-shorts seemed to be those involving the pliable lead bands connecting support wire to electrode post or another support wire. These bands are usually used long enough to provide necessary slack for running them around other supports. In some cases the cathode bands are curved to avoid the control grid supports, only to be curved too close to each other. If the cathodes are at an appreciable voltage difference with respect to each other, their bands may touch from expansion or the electrostatic pull between them. In pentagrid tubes, with numerous electrode posts, the cathode band is very often quite close to a support wire.

Approximately 100 of the tubes removed from the ENIAC had near shorts. Percentages of these failures for each type of tube indicate that near shorts are of general occurrence in all types.

Failures discussed here are those in which tubes investigated showed an internally open connection between support wires and electrode

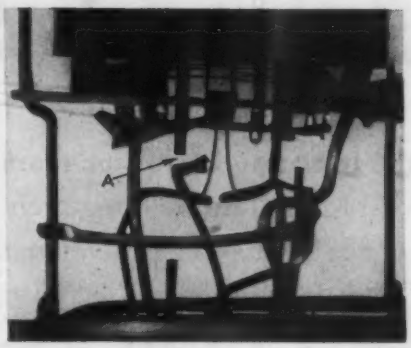

FIG. 5—Arrow points to control grid support of 6L6 pulled away from its post and providing near-short to adjacent heater

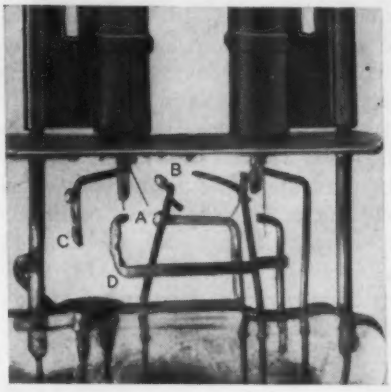

FIG. 6—Burned-open shorts in 6SN7 at heater (A), cathode band (B), control grid support (C), and heater band (D)

posts. No cases were found in which a lead band had pulled away from another wire.

Open Electrode Spotwelds

With open spotwelds (other than open heater-to-support spotwelds, already covered) it was not possible to identify definite characteristics of the opened spotwelds that might indicate faulty welds, though discoloration from the heat of the weld was seen.

Records of the rate of these approximately 50 failures with time show no significant tendencies, and the distribution among the various tube types is in rough proportion to the relative number of the tubes of each type employed in the ENIAC.

A few cases were found in which the screen support had pulled away from the screen grid post, and consequently touched or nearly touched the plate support. In most cases the size of the bend in the screen support decided whether it shorted or not.

Figure 5 shows a control grid support, having pulled away from the control grid post, in a position near shorting the adjacent heater wire. A little drop of metal fastened to the underside of the support presumably was part of the joint and under intense heat melted, allowing the support to snap away from the grid post.

Burned-Open Shorts

Initial reasons for these shorts were usually burned away, hence a separate classification was made even though causes may have been one or more of the faults previously taken up. Tabulation gave a random distribution of failures with time, in rough proportion to the numbers of tubes of each type in the ENIAC.

An interesting example of what a short can do is shown in Fig. 6. The left-hand side of the structure is completely burned open; the heater (A), the cathode band (B), and the control grid support (C) are burned open, leaving only the plate support intact. Molten droplets can be seen on the remaining wires, forced upward by the pressure of the burning. This burn continued down into the glass press, melting the surface around the supports.

This short might have been caused by an overhanging end of the heater band (D) touching the control grid support during vibration or expansion. The difference of potential across this band segment could have been as much as 150 volts.

Most burned-open wires encountered were of the lead band type which had probably expanded and touched another support or band. The kind of burned-open short pictured in Fig. 6 was the second most frequently occuring.

The author wishes to acknowledge the helpful criticism given by Thomas Kite Sharpless of the Moore School of Electrical Engineering Research Division, University of Pennsylvania, who is chief engineer of the EDVAC project (Electronic Discrete Variable Computor—a faster, more compact, and more versatile successor to the ENIAC). Appreciation is also expressed for the untiring efforts of Viola Andreoni, project worker.

Spiral Sweep

The time difference between the initiation of two or more positive pulses can be determined to within 0.05 microsecond by photographing their display on a single spiral trace revolving once every 2 microseconds and having a total length from 25 to 100 microseconds

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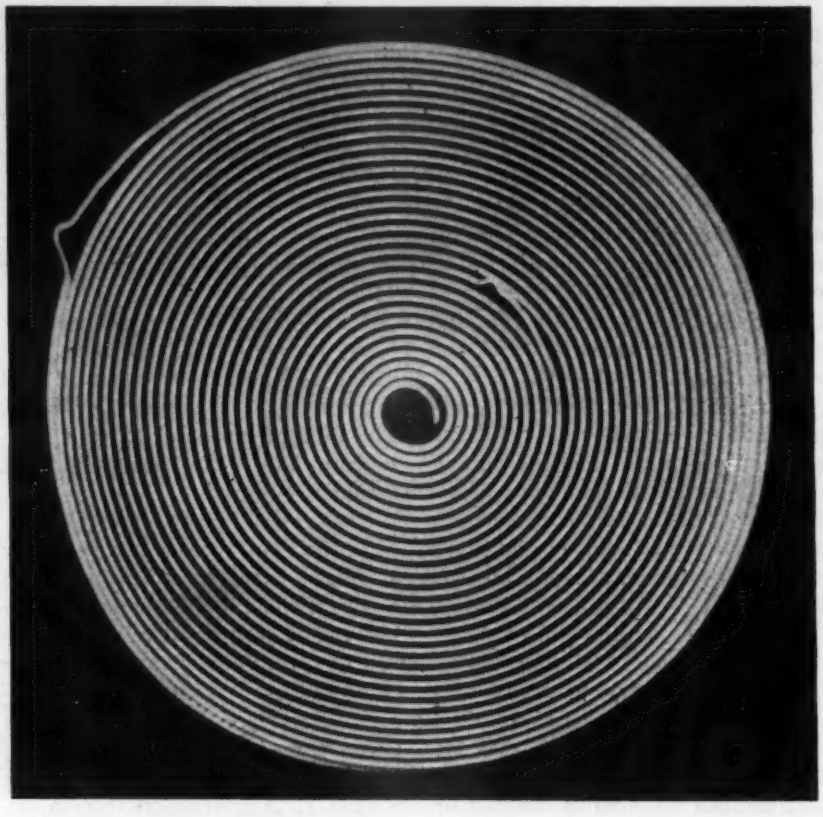
THE fields of electronics and nuclear physics both require extremely accurate measurement of time intervals between pulses that are in themselves only a matter of microseconds in length. The timing equipment to be described has been designed particularly for cyclic or aperiodic phenomena requiring a photographic record that can be scaled and interpreted at leisure.

A spiral sweep was chosen for the display of the intelligence because of the great effective length that can be recorded at one exposure and for the ease with which the record can be measured without the introduction of separate time markers. This latter advantage results from the fact that the angular velocity of the spot is constant and can be accurately standardized by suitable control of the sweep oscillator frequency. In practice, an enlarged photograph (shown) is made of the cathode-ray tube face and the time difference between successive pulses is read by simply counting off the number of complete revolutions and adding the time represented by the residual angle. A transparent protractor calibrated directly in hundredths of a microsecond is placed on the photograph for this purpose.



Representative photograph of the cathode ray tube display. The spacing between the pulses represents a time interval of 38.55 microseconds

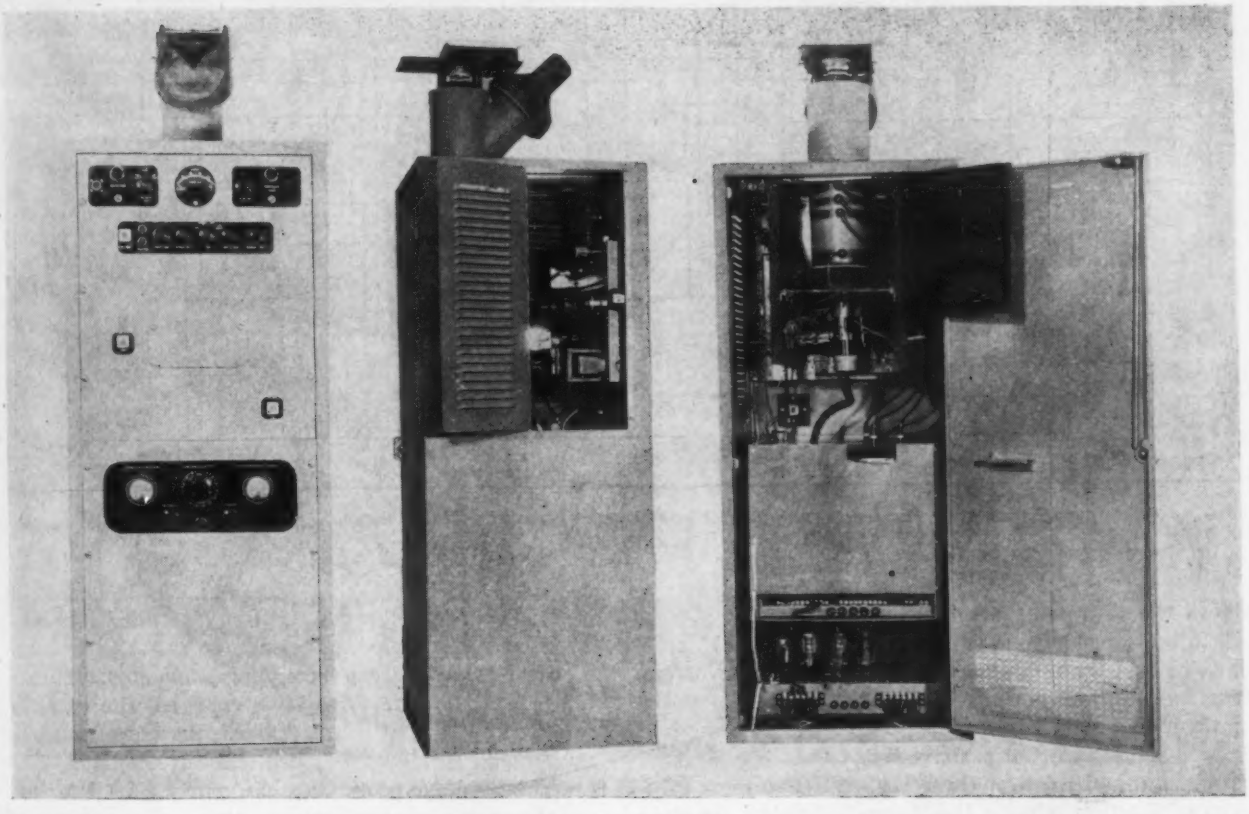
A DuMont type 5RP11 multiband cathode-ray tube is employed because it has the highest writing speed suitable for photography. Writing speeds as high as 100 inches a microsecond have been obtained, although the equipment described was constructed for phenomena whose total life encompasses 25 to 100 microseconds. With the sweep driven by a 500 kilocycle crystal oscillator, an accuracy of better than 0.05 microsecond has been obtained, provided that the pulses themselves have a comparable rise time.

Block Diagram

Operation of the spiral sweep oscilloscope is best understood by dividing the circuit functions into the units indicated on the block diagram, Fig. 1. The trip selector determines the method by which the oscilloscope is to be triggered. The trip pulse generator supplies a suitable negative pulse with a very steep front to operate the single-shot gate multivibrator that supplies a square positive pulse to the grid of the cathode-ray tube. This impulse turns on the beam that is normally cut off. At the same time, the gate multivibrator supplies the sweep generator with a negative square-wave pulse of the same length. The sweep generator supplies a single linear trapezoidal pulse of the same length as the gate pulse, and of variable amplitude.

The crystal controlled timing oscillator runs continuously at 500 kilocycles, and supplies the modula-

Oscilloscope Timer



Front, side and rear views of the equipment showing the viewing hood and camera above the top of the enclosing cabinet

ting amplifier with an accurately timed signal of constant amplitude. This amplifier modulates the 500-kc sine wave with the negative sawtooth wave from the sweep generator in such a way as to produce a 500-kc sine wave that decreases linearly in amplitude with time during the recording interval. The modulated signal is fed into a phase shifting network that splits it into two balanced outputs 90 degrees out of phase. These two outputs are then fed into the radial pulse injection amplifier which superimposes the signal pulses to be measured on the 500-kc sweep voltages in such a way that the pulse will record radially and have a fixed amplitude at any time it appears in the sweep cycle. The output of the pulse injection amplifier is fed directly to the deflection plates of the oscilloscope tube. A damping circuit tends to pass only positive pulses and therefore damps oscillatory wave trains that may be shock excited in the field circuits. The negative pulse input jack is provided for direct control of the cathode-ray tube grid in order that times may be indicated by producing blank spaces in the record.

• A schematic circuit diagram of the tripping, gate and sweep generators is shown in Fig. 2. A sharp negative trip pulse is generated by discharging C_1 through R_1 and the thyratron V_1. The trip selector S_1

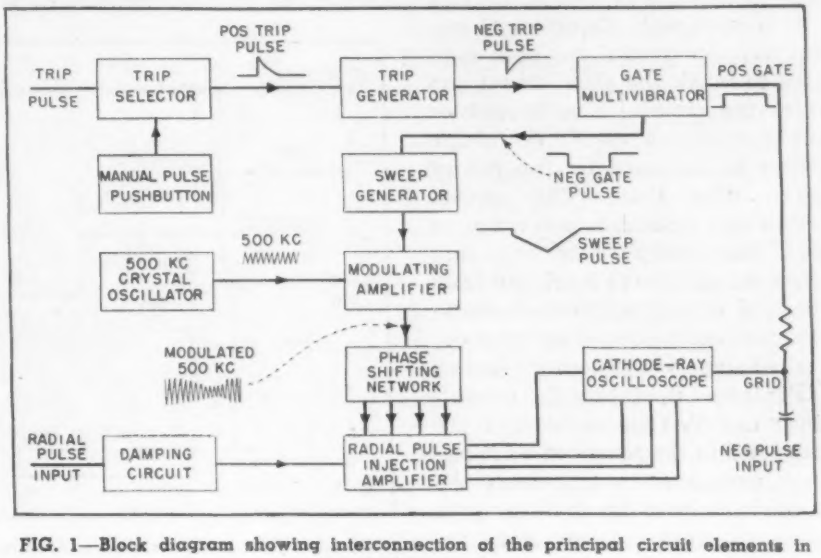


FIG. 1—Block diagram showing interconnection of the principal circuit elements in the spiral sweep timer

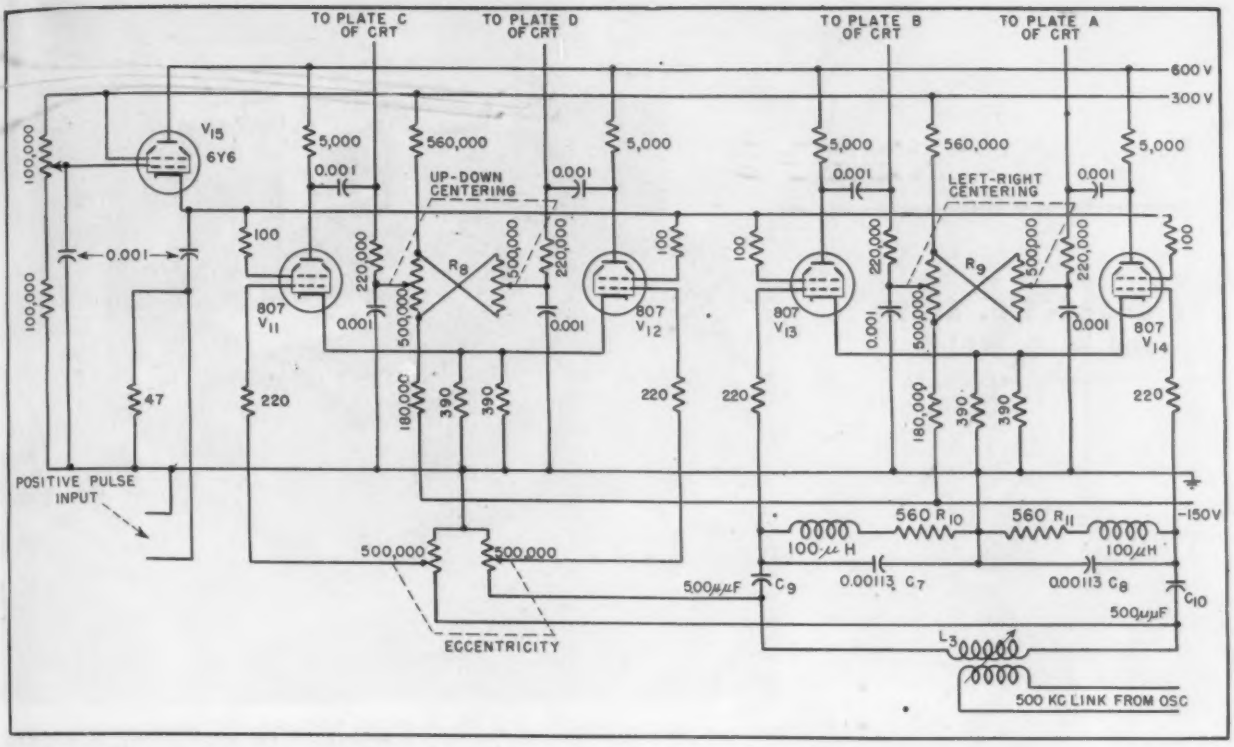


FIG. 4—Radial pulse injection amplifier that is connected to the cathode-ray tube. Positive input pulses to be timed are injected on the screens of the amplifiers, causing an aberration in the normal spiral traced by the electron beam

furnished the modulating amplifier by V_{8B} and its amplitude is controlled by the spiral rate control R_5. The initial bias of this negative pulse lead is controlled by the circle size control R_6.

Output from a conventional Pierce oscillator (Fig. 3) operating at 500 kc and stable to one part in 10,000, is fed through a cathode follower V_{9B} to the screen of V_{10}, the grid of which is connected to the sawtooth sweep circuit. The resulting modulated wave, of a form indicated in Fig. 1, is fed through a low impedance line to the injection amplifier unit.

Radial Pulse Injection Amplifier

The sweep-modulated 500-kc signal passes into a permeability tuned phase shifting network (Fig. 4) which is balanced to ground. Because L_1 C_7 and L_2 C_8 are tuned to 500 kc they are resistive at the fundamental frequency. Since L_3 is tuned to 500 kc by C_9 and C_{10}, the current in the resistive mesh will be 90 degrees out of phase with the voltage developed across L_3 which is applied to the grids of V_{11} and V_{13} through the eccentricity control R_7. The purpose of the grid networks L_1 C_7 R_{10} and L_2 C_8 R_{11} is to give equal frequency discrimination to any harmonics that may be present in both branches of the phase shifting network and thus reduce the amount of distortion of the circle pattern.

The push-pull vertical deflection amplifier (V_{11} and V_{12}) is in phase with the 500-kc tuned circuit voltage, whereas the horizontal amplifier (V_{13} and V_{14}) is 90 degrees out of phase. Therefore when their equal outputs are applied to the deflection plates of the oscilloscope tube, a circular deflection pattern is produced. Since the 500-kc input is modulated by a single sawtooth, during the recording interval this circular pattern will degenerate into a linear spiral during the interval that the beam is turned on.

The screens of all the deflection tubes are fed from a common cathode follower V_{15}. Thus, when a positive pulse is fed in on the screen bus through the input jack, the plate current is increased instantaneously in all of the amplifier tubes and the beam is deflected radially. This same cathode follower serves to damp oscillatory wave trains originating in the input circuit and to sharpen the breaks in the recorded pulse signals.

All operating controls and external connecting points appear on the front panel. A sweep control gives four different total sweep times of 30, 50, 75, and 100 microseconds. The equipment can be tested using a 60-cycle source that will repeatedly trip the sweep. The manual tripping control is used as a final check just before a photographic recording. The external position can be used with an oscillator or pulse generator, whereas aperiodic impulses are connected through the single-trip channel to avoid double exposure resulting from spurious signals following the desired pulse.

Acknowledgements

Credit should go to the entire development, Pasadena Task Group of the Electronic Section, U. S. NOTS, Inyokern, as almost everyone in the group has contributed in some way to this project. Special credit should go to Owen Peet, Walter Lovingfoss, and Joseph Strapp who did the major part of the construction and testing and furnished useful suggestions.

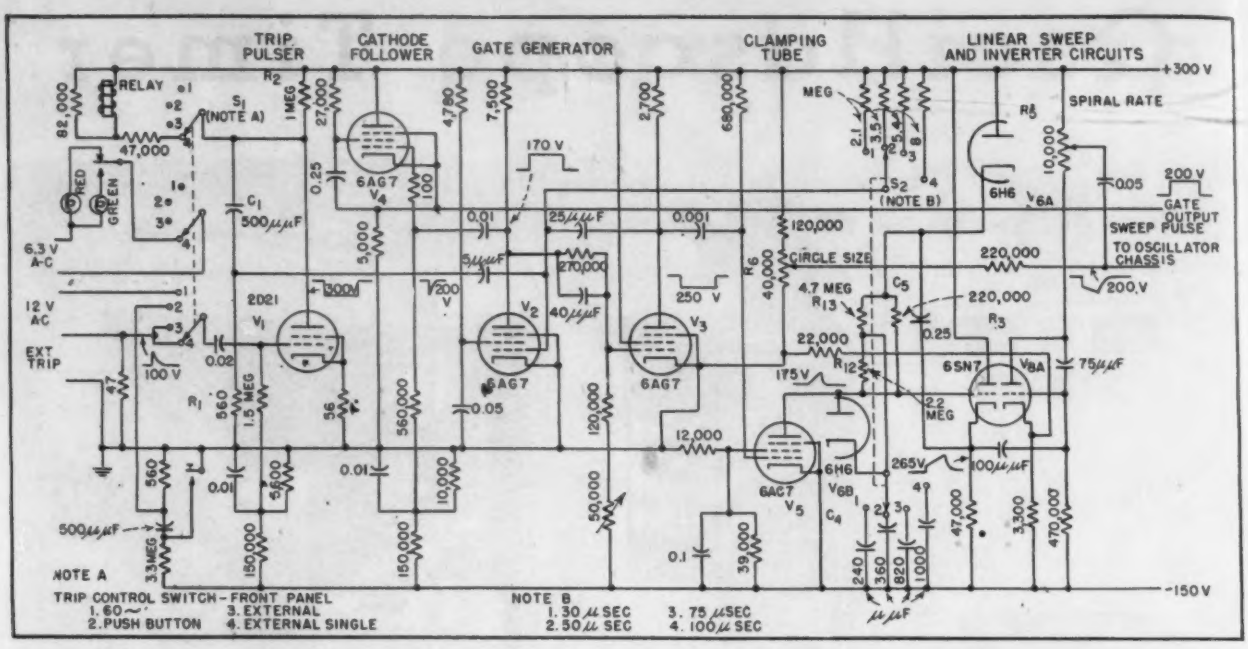


FIG. 2—Sweep generator that is triggered by any one of four different types of impulse. Sweep length is variable depending on position of S_2

allows the thyratron, normally cut off, to be tripped from the 60-cycle line, by the manual trip button, from any positive trip pulse train fed in through the external trip jack, or by a single external positive trip pulse. In any of the first three positions of the trip selector the thyratron V_1 goes out after C_1 has discharged because charging resistor R_2 is so large that the current is too small to sustain ionization. In the single trip position of S_1, C_1 is charged through a relay and a comparatively low resistance. The total plate load resistance of the thyratron is now low enough so that an arc is sustained. Capacitor C_1 can not recharge until S_1 has been operated to break the plate circuit and reset the circuit. The tripped or ready condition of V_1 for single pulses is indicated by the red or green pilot light. This circuit serves as a lockout to prevent more than one sweep from occurring when the equipment is tripped from the field circuit which may generate some extraneous pulse after the desired signals have been generated.

Pentodes V_3 (normally conducting) and V_4 (nonconducting) are connected in the circuit of a square-wave generator to transform the negative trip pulse into a gate pulse of length determined by capacitor C_3 and the timing resistor R_4 which is chosen by S_2. Cathode follower V_4 effectively isolates the generator from the cathode-ray tube.

Sweep Generator

Clamping tube V_5 is normally conducting, its plate being at a potential about 20 volts above its cathode. When it is cut off by a negative gate from V_3, its plate suddenly rises to the potential to which C_4 is charged. The height of this initial rise is determined by the voltage divider R_{12} and R_{13}. When the plate of V_{6B} goes positive with respect to its cathode it conducts and C_4 is charged through R_3. Tube V_{8A} is coupled to the cathode of V_{6A} by a "boot-strap" coupling capacitor. Therefore, as C_4 is charged, the cathode of V_{6A} is raised above the B+bus and V_{6A} then ceases to conduct. The boot-strap action of V_{8A} keeps a constant voltage across R_3 tending to maintain the charging current of C_4 constant in order to generate the desired linear topped sweep pulse. When the sweep length selector switch S_2 adjusts the value of C_4 it also selects a value of R_4 which will make the gate pulse just long enough to allow C_4 to charge to full voltage. A negative sweep pulse is

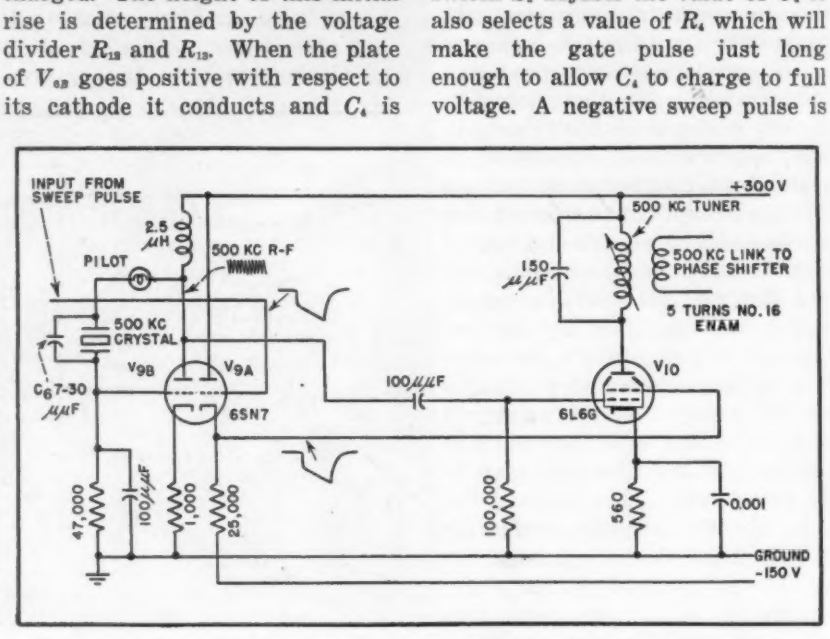
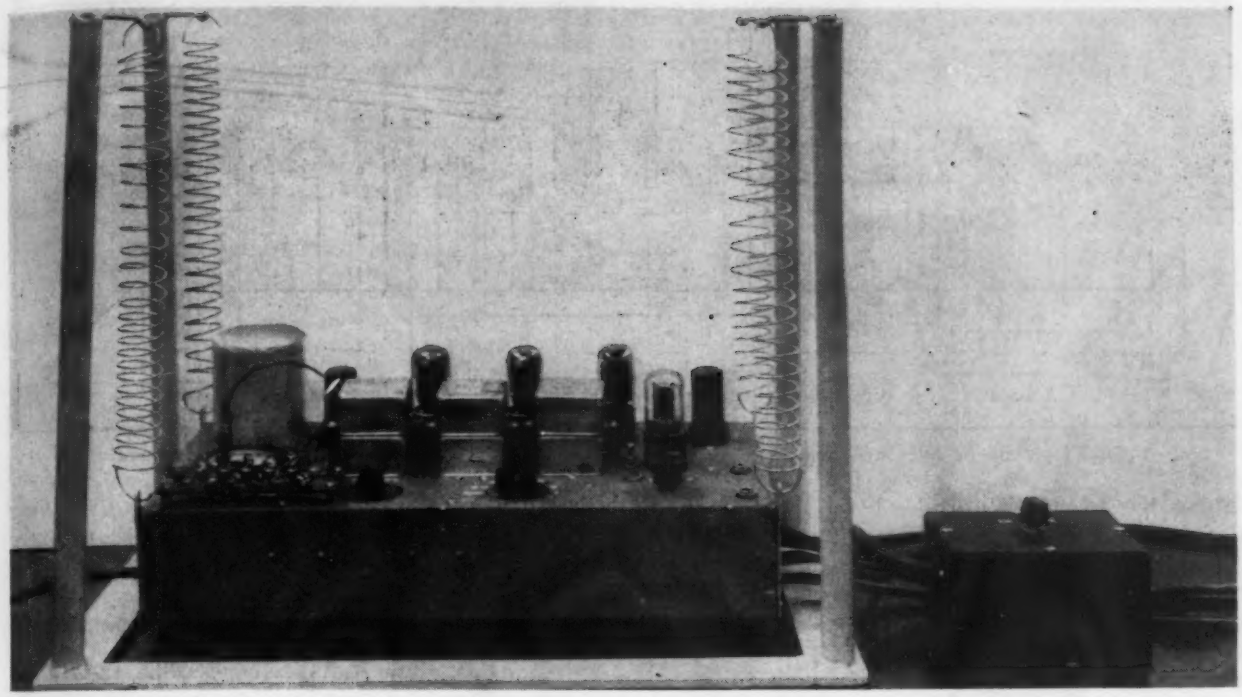


FIG. 3—Crystal oscillator and modulator for combining the 500-kc component with the sweep pulse from equipment in Fig. 2



Chassis suspension system has long period to prevent microphonics in this carrier-type d-c amplifier operating at 12 or 24 cps

Bandwidths of only a few cycles, input impedances not over 20 ohms, and averaging rectifiers are used to minimize noise when amplifying signals below a microvolt. Speed of amplifier response is analyzed. Construction of two laboratory amplifiers is described

quencies in the vicinity of 60 cycles are to be avoided because of the universal presence of hum fields from power circuits.

One of the most important design aspects affecting the level of circuit noise is the rectifier used at the amplifier output to convert the a-c into d-c for actuating an indicator or recorder. Peak-type diode voltmeters accentuate the noise component more than averaging rectifiers, so the averaging type is preferred. Perhaps the best rectifier from the standpoint of minimizing noise is the mechanical rectifier; it is a motor-driven switch operated from the same shaft that drives the mechanical shutter. The switch thus reverses the polarity of the amplifier output in synchronism with the a-c signal generated by the shutter so that the output is rectified on a purely average basis, independently of the absolute value of the signal. The mechanical rectifier is strictly linear, and when used with a filter, provides selectivity dependent only on the characteristic of the filter.

Input Circuits

Balanced input circuits and a suitable input transformer are essential if maximum sensitivity is to be realized when the amplifier is connected to thermal receivers or other devices of low impedance. The stepup of this transformer should be high, so that the irreducible thermal noise across its input terminals is made large enough to override by a substantial margin the noise generated in the first vacuum tube. For operating frequencies of 10 cycles or above, this condition is easily fulfilled, and it is then unnecessary to take extreme precautions to reduce tube noise to the lowest possible level.

The transformer used is the Thermador Type TG-3, originally intended for geophysical use. It has a six-element shield and a rated secondary inductance of 2,400 henries ±10 percent, at low voltages. The stepup obtainable from a balanced 10-10 ohm input circuit is 150 at 50 cycles, 107 at 12 cycles, and 84 at 7 cycles, the secondary being tuned for maximum output in each case. However, unless the secondary Q is greater than two,

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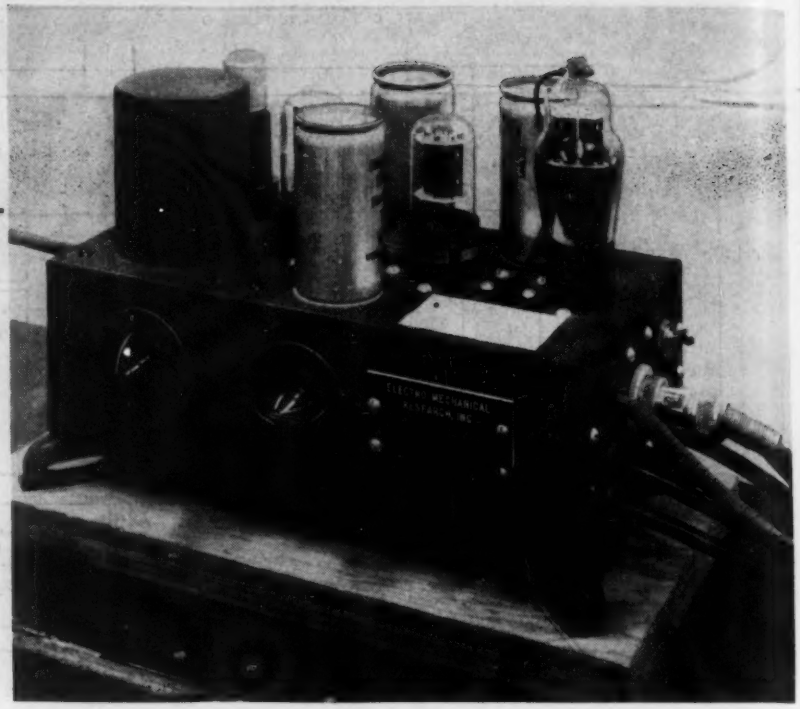

Compact low-frequency amplifier uses a battery for the plate supply of low-level stages to dispense with bulky decoupling filters

D-C AMPLIFIER for Low-Level Signals

AMPLIFIERS for extremely low input levels are often required in the measurement of physical quantities in both research and materials testing laboratories. One important field of instrumentation where such amplifiers are required is the measurement of various forms of radiation.

Design Considerations

The conventional method of using an a-c amplifier instead of a d-c type is to modulate a local high-frequency carrier with the input signal, amplify the modulated a-c, and finally obtain the signal by detection. Recently the thermal time constants of bolometers and thermocouples have been substantially reduced, so it is possible to interrupt the radiation falling on them, by means of a mechanical shutter for example, and thus directly obtain an a-c output that is proportional to the incident radiation.

To measure minute amounts of radiation, such as those involved in astronomical investigations, it is necessary to deal with signals of the order of millimicrovolts. To distinguish such signals in the presence of noise, it is necessary to employ an exceedingly narrow bandwidth in the amplifier. The frequencies of operation of the newer bolometers and thermocouples range from 5 to as high as 150 cycles. During the course of work on a National Defense Research Committee contract, amplifiers for use with these bolometers and for general testing at low frequencies were developed; the amplifiers operate at frequencies below 50 cps with bandwidths less than 5 cps wide. Although these units are of specialized nature, they do have many uses in instrumentation beyond the purposes for which they were originally designed.

In electrical design, it is desirable to operate at as low a frequency as possible, because the minimum achievable bandwidth becomes narrower as the operating frequency is lowered, thus reducing the noise against which the signal must compete. But too low a frequency presents apparatus problems, particularly in the design of the input transformer and in the size of the by-pass capacitors. Fre-

synchronous rectifier, the phase of the impressed voltage must be correct. For this reason the amplifier should be provided with a continuously variable phase adjusting network so that the correct relationship between signal and rectifier phase can be easily reached, and so that effects of small drifts in the tuning of the amplifier, or slight changes in the operating frequency, can be compensated.

If full advantage is to be taken of the useful characteristics of the rectifier-filter system, it is essential that there be no interference, either microphonic or electrical, from the rectifier itself. Such interference, being synchronous, is very detrimental and great care must be taken to avoid it.

Speed of Response

There is no simple relation between the effective overall time constant of the amplifier and the bandwidth at some specified amplitude, such as 3 decibels down, or 6 decibels down. However, certain simple formulas make it possible to decide on the approximate value of bandwidth to be employed when a given response speed is required.

When a sinusoidal electromotive force is suddenly impressed upon a series-tuned circuit, the resulting current consists of a steady-state term plus a transient term, which gradually dies away. The transient is of the form of a damped sine-wave, and the time constant t_1 of the circuit is the time required for the amplitude of the transient to decrease to 37 percent of its initial value. Let f_2 and f_1 be frequencies at which the resonant curve of the tuned circuit falls to a fraction F of its maximum. If X is the total reactance around the circuit at either one of these frequencies

$$F = 1/(1 + X^2/R_1^2)^{1/2} \qquad (1)$$

from which two relations follow

$$(2\pi f_2 L/R_1) - (1/2\pi f_2 CR_1) = (-1 + 1/F^2)^{1/2} \qquad (2)$$

and

$$(1/2\pi f_1 CR_1) - (2\pi f_1 L/R_1) = (-1 + 1/F^2)^{1/2} \qquad (3)$$

adding these two expressions

$$[2\pi f_2 L + 1/2\pi f_1 C] - [2\pi f_1 L + 1/2\pi f_2 C] = 2R_1(-1 + 1/F^2)^{1/2}$$

furthermore $2\pi f_2 L$ is very nearly equal to $1/2\pi f_1 C$, and $2\pi f_1 L$ is equally close to $1/2\pi f_2 C$, hence

$$f_2 - f_1 = (R_1/2\pi L)(-1 + 1/F^2)^{1/2} \qquad (4)$$

in addition, the rise of current in the circuit is determined by the time constant t_1 which is $2L/R_1$; this term can be used to eliminate L/R_1 from Eq. 4 giving, on rearrangement

$$t_1 = (-1 + 1/F^2)^{1/2}/\pi(f_2 - f_1) \qquad (5)$$

which equation relates time constant to bandwidth. For half-amplitude bandwidth $F=0.5$ and Eq. 5 gives

$$t_1 = 0.552/(f_2 - f_1)$$

showing that a frequency response one cycle wide at half amplitude gives an effective time constant of slightly over half a second. If bandwidth is considered to be between the 3-db points, then $F=0.707$

$$t_1 = 0.318/(f_2 - f_1)$$

which results indicate that, for a given definition of bandwidth, the time constant depends, as does the noise, on the absolute bandwidth.

Response of Synchronous Rectifier

The synchronous rectifier used with this amplifier and its associated filter also has an effect on the response time of the system. When the voltage impressed on the mechanical rectifier is synchronous with the rectifier switching, as will always be the case with the desired signal, the output will contain a direct-current term. If a signal is suddenly impressed on the rectifier, the voltage appearing across the output of the filter will require some time to reach its maximum value. The time constant t_1 is the interval required for the output to reach 63 percent of its final value.

If the filter consists of two identical resistance-capacitance networks, the ratio of the instantaneous output voltage to the impressed direct voltage is

$$e_2/E_0 = 1 - \epsilon^{-1.5t/RC} \times [1.342 \sinh(1.118t/RC) + \cosh(1.118t/RC)] \qquad (6)$$

from which it can be found that the output reaches 0.63 of its final value when $t/RC=3.03$, hence t_1 is $3.03RC$ for this filter.

To relate this time constant to the effective selectivity, let f_0 be the synchronous frequency, and f_1 and f_2 be the higher and lower frequencies of the incoming signal at

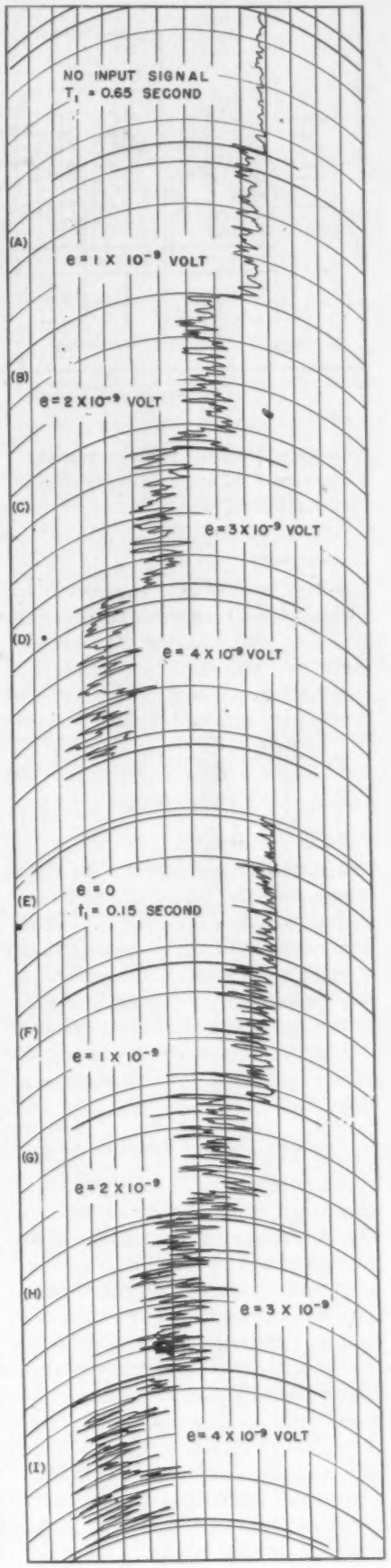

FIG. 2—Output from amplifier of Fig. 1

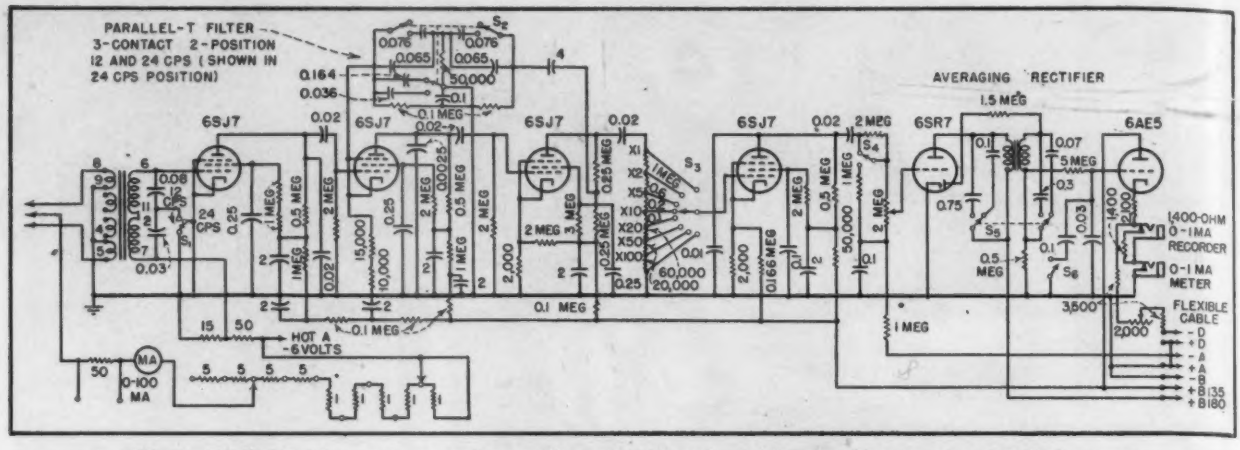

FIG. 1—Parallel-T filter and averaging rectifier minimize noise in this amplifier for use with bolometers

tuning the secondary provides little improvement.

The layout of the amplifier should take account of the obvious precautions required in any high-gain device, such as in-line sequence of stages, adequate separation of high-level and low-level regions, and shielding of critical elements. Moreover, at the gains involved here, certain additional precautions are necessary, especially in the first stage, although it has been found that elaborate constructions are not always necessary. In some cases, protection provided by the sextuple shielding on the transformer, the metal case of the first tube, and a standard metal chassis enclosing the transformer tuning capacitor and the wiring has proved satisfactory, provided the device is not subjected to severe electrical interference. In other cases, moderate additions to this shielding have been necessary.

Tubes recommended for the first stage are the 6SJ7 and the 1620. It is desirable to test tubes for electrical and microphonic noise, and to select the quietest units, because individual tubes differ greatly.

A very substantial plate decoupling filter is required in the first stage; the second stage is also apt to call for special attention in this regard. The necessary filtering can be realized either by using two or three sections of R-C filter (multiple sections require less total R and less total C than a single section of the same effectiveness), or by using gas voltage-regulator tubes, which act as excellent low-frequency bypass elements.

It is well to use precision wirewound resistors in all parts of the first stage, except the sections of decoupling filter which precede the last section. Oil-filled by-pass capacitors should be used, and very high resistance mica coupling capacitors; capacitors having even a small leak can cause severe noise. The use of one-point grounds, as is common in high-gain radio-frequency amplifiers, is especially desirable.

Selective Circuits

In the first amplifiers constructed in our laboratories, inductance-capacitance selective circuits were used. Besides tuning the input-transformer secondary, the grid circuit of the third stage, which utilized the primary of a Thermador Type TG-26 transformer, was tuned. This type of tuning is simple and results in a fairly high gain. However, the inductance of the coil changes slightly with voltage level, thereby causing detuning and moderate nonlinearity.

In the later amplifiers, a twin-T selective feedback circuit has been employed for tuning purposes, usually from the plate of the third stage to the cathode of the second. Feedback from the third plate to the suppressor-grid of the first stage has also been successfully used. In most cases, a well balanced twin-T network gives sufficient selectivity. However, in some cases a narrower band was required; it was achieved by increasing the shunt capacitance in the twin-T circuit above the normally used value, which makes the feedback voltage regenerative near what would normally be the zero transmission frequency of the twin-T.

Signal Rectifier

Considerable use has been made of a simple peak-type diode rectifier, which is satisfactory unless it is necessary to measure signals just above circuit-noise level. Circuit noise contains peaks that are several times the average noise level. These peaks register on a peak-type voltmeter, and keep the rectified noise voltage unnecessarily high.

This difficulty can be remedied by arranging the diode to respond to the true average of the impressed alternating voltage by using a circuit in which no by-pass capacitors are used across the resistors in series with the diode. With amplification adjusted so as to obtain the same sinewave output in both cases, the average noise level with a peak rectifier was 74 percent greater than with the average-type rectifier, and in addition, the latter gave a more uniform noise level, relatively free of surges, than the peak type.

As has been mentioned, synchronous mechanical rectifiers have also been employed. This rectifier has been used successfully in the amplification of direct potentials that are interrupted, fed into an alternating-current amplifier, and then synchronously rectified. The rectifier and the filter to which its output is delivered give an effective selectivity to the amplifier which is determined entirely by the characteristics of the filter.

In order to get full output from a

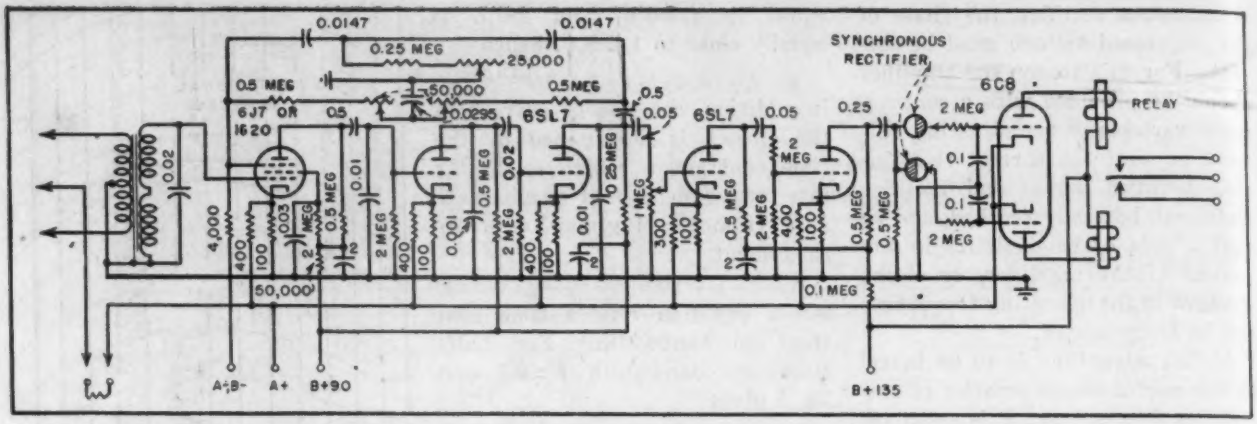

FIG. 3—Synchronous rectifier, consisting of two rotating commutators, averages noise in amplifier output

which the filter output is reduced to a fraction F of its maximum steady state value. Then

$$F^2 = 1/\{1 + 28[\pi RC(f_2 - f_0)]^2 + 16[\pi RC(f_2 - f_0)]^4\} \quad (7)$$

and also an identical expression in which $(f_0 - f_1)$ appears in place of $(f_2 - f_0)$. Eliminating f_0 between these two similar expressions and eliminating RC by means of the previously obtained time constant

$$t_1 = [3.03/\pi(f_2 - f_1)] \times [-3.5 + (11.25 + 1/F^2)^{1/2}]^{1/2} \quad (8)$$

which, for $F = 0.5$, gives

$$t_1 = 0.614/(f_2 - f_1)$$

corresponding roughly to the time constant of the tuned circuit at its half-amplitude bandwidth. The time constant of the two-mesh filter is slightly greater than that of a single-mesh one, however this disadvantage is offset by the greater attenuation of the synchronous frequency provided by the two-mesh filter.

Description of Amplifier

The circuit of a two-frequency laboratory amplifier is shown in Fig. 1. A spring suspension used to support it has sufficient stiffness to provide a period of 0.8 second for oscillations in the vertical direction. This gives adequate protection against ordinary mechanical disturbances. Construction and layout are not greatly different from those of any ordinary low-gain amplifier, the chief difference being that the output transformer (which feeds the rectifier) is mounted in an entirely separate box to prevent objectionable magnetic coupling with the input.

It is to be noted that both the bolometer current and the grid bias for the first stage and for the fifth stage are obtained from the A-battery, without developing trouble from feedback. The bias connection to the fifth stage is rather heavily filtered, however.

No by-pass capacitor is provided in the rectifier circuit, so that the direct voltage developed is proportional to the average value of the signal. A part of this voltage is impressed, through a low-pass filter, upon the grid of the output tube. Switch S_6 allows the time constant of this filter to be set at either 0.15 seconds or 0.65 seconds.

The frequency of maximum amplification can be changed from 12 to 24 cycles by switching capacitances in the twin-T network, across the secondary of the input transformer, and across each winding of the output transformer. Because maximum amplification is often not required, the switch S_5 has been provided to lower the gain by a fixed amount. Further adjustment to a desired sensitivity is made by the volume control in the grid circuit of the fourth stage which is composed of precision wirewound resistors, and provides attenuations up to 100 times, as indicated in the circuit diagram.

Performance Data

Full-scale deflection of the output meter is obtained with 0.05 microvolts developed in a 10-ohm resistor in one side of the balanced input circuit, with the attenuator at 0.1. When there is no attenuation, and the impressed signal is reduced to 0.005 microvolt, the total deflection obtained is greater than full-scale (because of the addition of the circuit noise to the signal), but we can rate the maximum full-scale sensitivity as 0.005 microvolt. When 24-cycle tuning is used, the sensitivity is 0.0042 microvolt.

Figure 2 shows a record of the 12-cycle circuit noise made with a recording milliammeter when the input cable is terminated in a pair of 10-ohm wire-wound resistors. The average noise voltage is 1.1×10^{-9} volt. Figures 2B to 2D, inclusive, show the result of adding successively greater amounts of signal. It will be noticed that a signal of 0.001 microvolt can be very definitely detected, although it is not greatly above noise level. In these runs the time constant switch was in the 0.65-second position. Figure 2E to 2I, inclusive, show similar data except that the switch S_6 is in the 0.15-second position, and hence the oscillations of the recorder needle are more rapid.

Records of the noise level made with the secondary of the input transformer short-circuited, show it to be 3×10^{-10} volt, in terms of the equivalent primary circuit voltage or approximately a quarter the circuit noise developed with 10-10 ohm resistors at the input cable.

The average noise level indicated by the recordings is 1.1×10^{-9} volt on the 12-cycle channel, and 1.3×10^{-9} on the 24-cycle channel. The half-amplitude bandwidth of the former is 2.0 cycles, while the latter is 5.4. The root-mean-square thermal noise voltage in an idealized frequency band 2-cycles wide,

FOR TELEVISION

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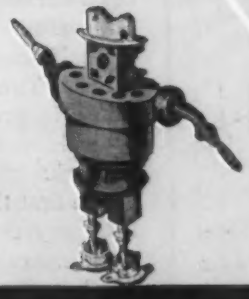

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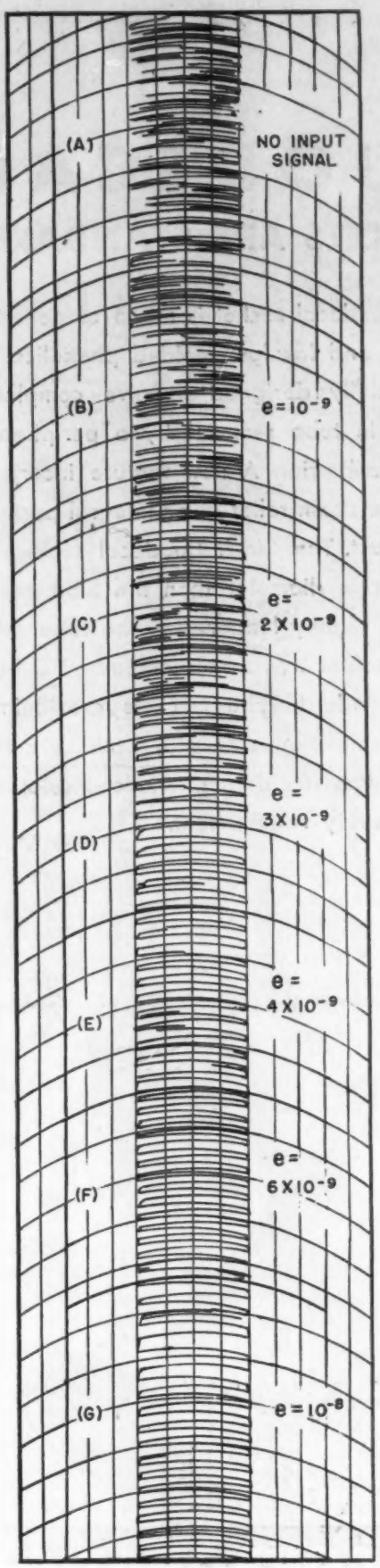


FIG. 4—Output from amplifier of Fig. 3

generated by a 20-ohm resistor, is 0.8×10^{-9} volt, while that corresponding to a 5.4-cycle bandwidth is 1.3×10^{-9} volt. It is necessary to consider the full 20 ohms of the two 10-ohm resistors in the input circuit, because the voltages they generate are in series with the primary, in the same way that the signal voltage developed in a 10-ohm thermal receiver is in series with the primary. The above figures show that the total noise of the amplifier approaches thermal limit.

The root-mean-square voltage across the secondary of the rectifier transformer corresponding to full-scale deflection of the recording milliammeter in the output of the direct-current amplifier stage is 46 volts. This means that the total voltage amplification from 10-ohm input circuit to transformer secondary is 9.2×10^{9}. Of course, not all of this gain is effectively used, because there is a four-to-one voltage division in the rectifier circuit proper, and because the direct voltage developed is proportional to the average value of the impressed alternating voltage, or to $2^{1}/\pi$ times the root-mean-square impressed alternating current. Hence the rectified voltage applied to the filter is only 5.2 volts, and the useful voltage gain may be taken as 1.04×10^{9}. However, the larger figure, relating to the transformer secondary voltage, is effective in determining the possibility of there being stray feedback of alternating voltages within the amplifier itself.

A Compact Amplifier

Figure 3 shows a small amplifier, having only four tubes, intended to be used with an external synchronous rectifier (shown as part of the diagram). The unit is designed for nominal 24-cycle operation, and the half-amplitude bandwidth is 4.0 cycles. Tuning over a 10 percent range is provided by the ganged variable resistors in the twin-T network.

The first three stages take a total B-battery current of less than 0.6 milliampere at 90 volts, and hence a small separate B-battery is used for them. Using a battery greatly reduces the amount of plate-circuit filtering that is required and avoids the necessity for numerous bulky capacitors.

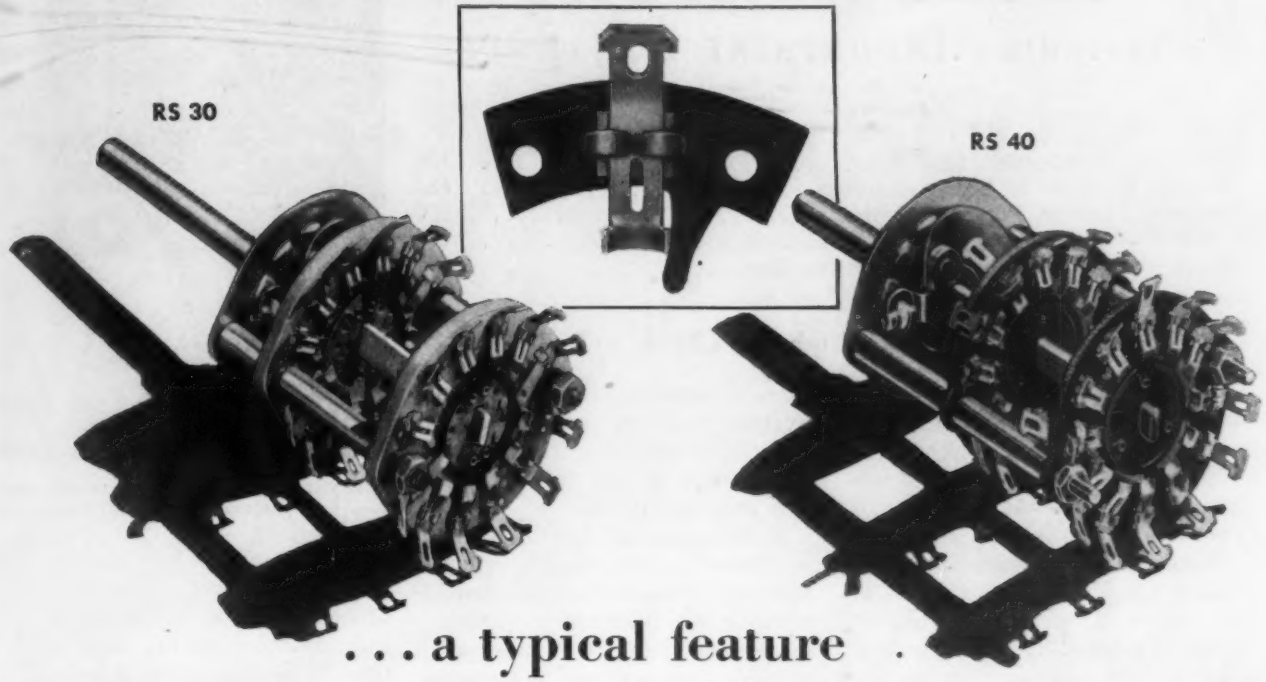
Because (1) no proportionality of output versus input was required with this device and (2) a rather wide range of input voltages had to be handled, the last stage was provided with a series grid resistor, and thus acted as a limiter. The next to last stage also limits somewhat on strong signals. The resulting phase shift with amplitude, while appreciable, is not enough to interfere with the action of the synchronous rectifiers. Ranges of input voltage in excess of one-thousand to one can be handled without difficulty.

There are two half-wave sections in the rectifier, each of which feeds a separate filter and a triode direct-current amplifier, so that one triode will respond to a signal of a certain phase, and the other to one of opposite phase. A differential relay with one winding in series with each output-tube plate is provided.

The amplifier was designed to give reliable operation on input signals down to 10^{-8} volt acting in one side of a 10-10-ohm balanced circuit. Actually, it does rather better than this, as is indicated by Fig. 4. Figure 4A shows the operation of a recorder connected to the differential relay. The pen moves in one direction when the relay closes due to current through the upper triode section and in the opposite direction when the relay closes on the other side. Because of the very high gain, circuit noise keeps the relay in operation always.

The frequency of the signal recorded in Fig. 4B was adjusted to differ by 0.2 cycle per second from that of the mechanical rectifiers, so that with a strong signal the relay and recorder move regularly back and forth. In Fig. 4B the change in the character of the record clearly shows the presence of a signal of 10^{-9} volt, although the operation can hardly be described as satisfactory. With twice as much input voltage, the regular pattern becomes more evident (Fig. 4C) although noise is still quite troublesome. With 3×10^{-9} volt (Fig. 4D), the operation is fairly good, and at 6×10^{-9} or more, it is substantially perfect.

TWO-POINT FASTENING



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that insures accuracy, dependability and long life

ONE thing you'll like about the RS 30 and RS 40 is the Mallory method of fastening the terminals. By means of heavy staples and round hole stator design, terminals are held securely at two different points so they can't twist or work loose. Proper contact alignment is thus also assured.

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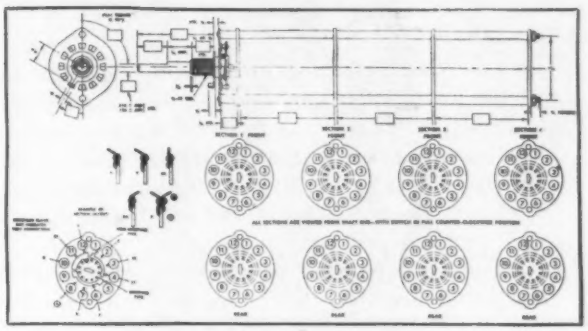
Both switches have high torque definite snap indexing, and both permit 12 terminals on either side per section. Insulation is different, however—the RS 30 featuring high grade ceramic, and the RS 40 having low loss phenolic. Write for RS engineering data folder. Many standard circuit combinations in Mallory RS 30 switches are obtainable from convenient Mallory distributors under catalog numbers 160C, 170C and 180C series.



Ask for RS Specification Sheets

Printed on thin paper to permit blueprinting, these sectional drawings indicate standard and optional dimensions—make it easy for you to specify Mallory RS switches built to meet your specific circuit and mechanical requirements.

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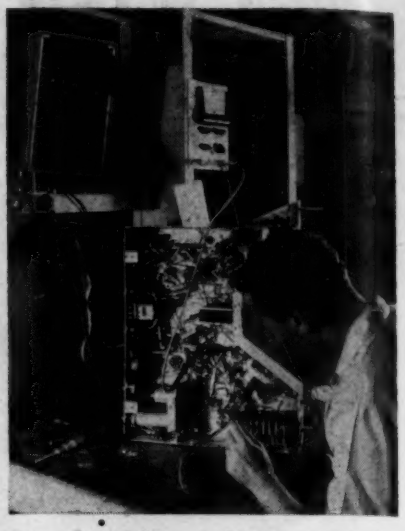
TUBES AT WORK

Including INDUSTRIAL CONTROL

Edited by VIN ZELUFF

Television Production Line 132
Locates Grounds in Shielded Room 134
General Purpose Portable Amplifier 150
Tube Production Techniques 160
Diode Contact Potential for Negative Bias 164



Trimmers, padders, and iron cores tuning the i-f stages are adjusted at this station

Television Production Line

POPULAR problem in the industry is that of converting drafting-room data into a continuous production operation resulting in finished television receivers. At RCA Victor, production supervisors with long experience in radio manufacturing helped simplify this job. With an average of 18 years of radio production experience, these supervisors supplied the know-how for making a systematic analysis that enabled the many operations to be broken down into individual assignments and the assembly line to be balanced.

In television assembly at the RCA Victor plant, each line, laid out as a double-return unit, consists of a belt conveyor moving at approximately 50 feet per hour past 80 assembly stations. Chassis are carried through practically all operations while supported on trunnion legs and inverted to bring the chassis bottom into convenient working position. Besides the 80 assemblers, each line also requires 8 inspectors, 3 wire dressers, 4 repair men, and 10 testers.

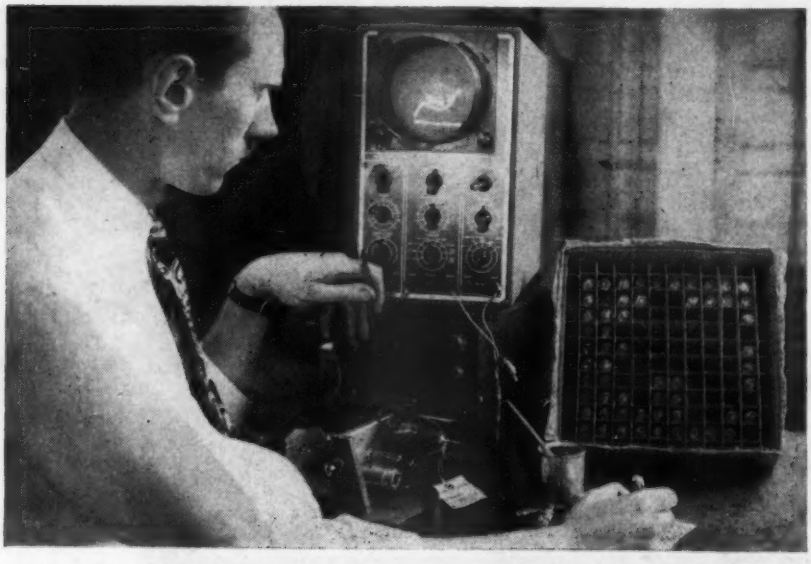
Most assembly operations are performed in 2-minute cycles, making a total chassis-assembly time of 160 minutes. Designed to eliminate batch production and work-area storage, conveyorized assembly paces production at a rate established by standard-data time values.

Mechanical Operations

Automatic riveting is the first assembly operation on chassis that have been formed, pierced, welded and cadmium-plated. Tube sockets and holders, terminal boards, ground lugs, a-c sockets and receptacles, electrolytic sockets, foot brackets and capacitor clamps, transformers and coil bases—a total of 66 pieces on the 10-inch chassis —are attached by brass-plated steel tubular rivets. Operations are broken down to 1-minute cycles, each operator having nine operations to perform in each cycle.

Mechanical operations require 10 of the 80 operators on chassis assembly for attaching parts and subassemblies, usually by air-gun nut runners or screw drivers for speed and ease. On the only fixture needed, the transformer is placed on an inclined block, the chassis inverted over it and the transformer bolted in place. Trunnion legs are fastened to each end of the chassis to carry it through subsequent operations on the belt conveyor.

Soldering and crimping wires are done by operators on a 2-minute cycle. All operations are timed by standard data. Each worker is guided by an operation sheet, placed directly in front of the station, that shows all joints to be soldered and wires to be crimped at that station. Work progresses from left to right on each chassis so the operator need not work at uncomfortable angles as the conveyor belt carries sets past his station. Wherever possible, the process is arranged so several operators crimp sufficient wires and parts so following operators need only solder.



Each switch-tuned front end consists of a subassembly which is here aligned to the frequency of channel 6. All 13 channels are aligned with an oscilloscope

Coil Winding

Tuning of the television receiver is done by a switch consisting of 7 stacks of wafers on which front-end coils are mounted to cover all 13 television channels. Twenty of the

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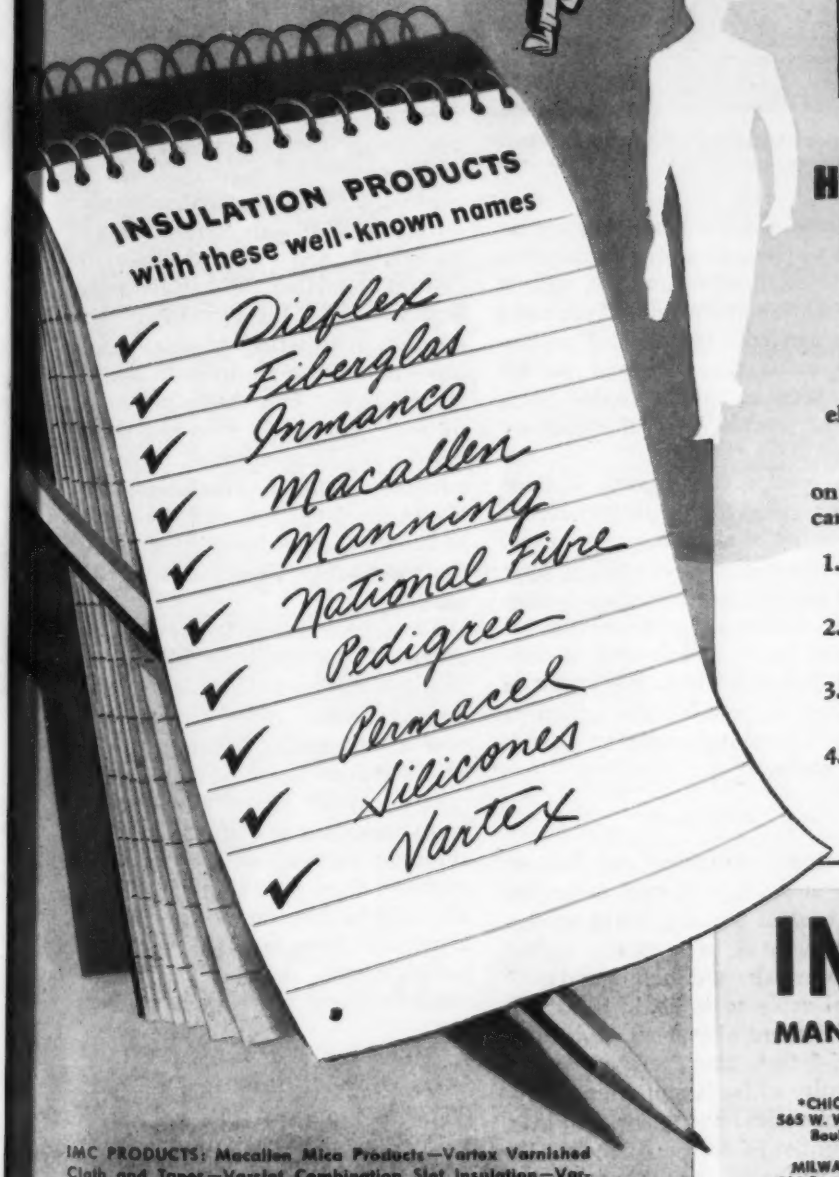

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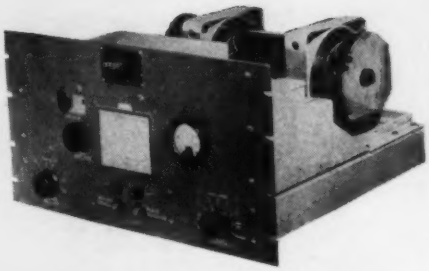

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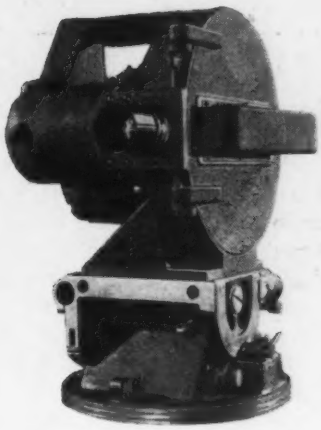
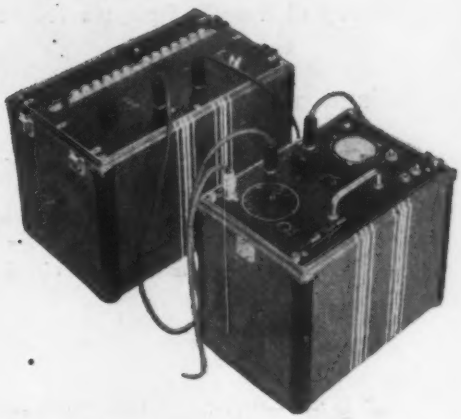
This new instrument provides a 100 kc reference frequency accurate to one part per 100,000,000 per day, regardless of moderate changes in ambient temperature, humidity and air pressure. Designed for time-frequency measurements or the synchronous operation of two or more independent systems.



FASTAX CAMERA

The world's fastest portable motion picture camera comes in three models: 8mm (up to 10,000 pictures per second); 16 mm (up to 5,000 pps); 35 mm wide angle (up to 3,500 pps). It bares secrets of fast-moving parts and short-duration phenomena. It's ideal for research, design engineering, and testing.



NOISE ANALYZER

Provides a simple, reliable means to measure the magnitude and frequency composition of noise. An optional vibration pick-up can be used to measure vibrations not accompanied by noise. Two models: RA-361, which operates from self-contained batteries, and RA-362, from 110 volt, 60 cycle line.

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Make possible greater accuracy and dependability of high speed switching machines and virtually eliminate relay maintenance problems. Hermetically sealed against dirt, immune to atmospheric conditions, tamper-proof, good for a billion or more operations, they assure high operating speeds and constant operating characteristics.

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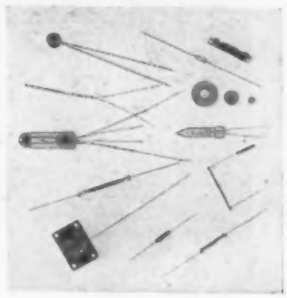
Ideal for temperature measurement, control and many other electronic applications. The resistance of thermistors varies greatly with changes in temperature—*decreasing* as temperature goes up, *increasing* as temperature goes down. They permit use of simpler, more economical electrical circuits than are possible otherwise.



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As the conveyor belt carries the chassis past this assembly station, the operator crimps into place the parts indicated on her operations sheet which remains in view at all times

In the deflection test, the test pattern from the monoscope shows vertical and horizontal linearity, contrast, resolution, definition, and transient interferences

coils mounted on the switch wafers have non-inductive windings in the form of a double-reverse figure 8. When pilot-model coils, each one smaller than a finger nail, were first made by hand, girls became wire-happy as the winding motion was not rhythmic.

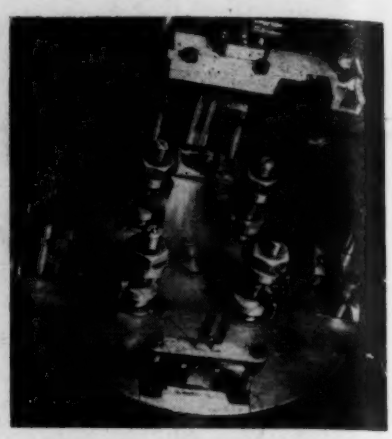
The machine illustrated winds from 450 to 1,800 coils per hour, depending on the number of turns required. A finger, through which the wire passes, winds each coil over the projecting prongs. The plate indexes to the next position where the coil is compressed and set with a hot molding compound. Two more indexings cool the molded coil, a blade snips the wire and an air blast pops it into a basket as a plunger pushes it off the winding prongs.

The switch subassembly is built up on a metal fixture in 9 stations: 3 crimping, 3 crimping and soldering, 2 mounting wafer stack in base and 1 mounting end plates. Assembly is followed by inspection of soldered joints and testing of electrical characteristics. Each unit is balanced by peaking the trimmers for all 13 channels with an oscilloscope setup.

Alignment

Testing operations are broken down into i-f, r-f, and deflection tests, each of which is based on signals generated in a master signal generator cage and distributed over coaxial cable to individual test locations where alignment is done.

In i-f test, the operator checks continuity of leads and aligns various trimmers and powdered-iron cores in the i-f section of the set by using as basis for alignment an image signal generated by a master oscillator.



Indexing plate and jigs of the winding machine for the figure-8 coils used for tuning to the television channels

Deflection test is the final chassis electrical test in which the test pattern, from a monoscope generated in the signal generator cage and piped by coaxial cable to test cages, permits perfect balancing. As reproduced on the screen of the receiver, the test pattern should show circles round and concentric for horizontal and vertical linearity and no distortion. The radial resolution-wedge lines should be straight and distinct to obtain good black and white contrast in closely spaced lines. The shading wedges in black, gray, light gray and white are for checking contrast, while the numbers indicate resolution, the blocks the definition, and the parallel lines any transients due to ignition and other electrical interference.

From test, assembled chassis go overhead, conveyed on trolleys to final assembly where cabinets, television chassis, radio chassis and phonograph units (for the console) are assembled on conveyor lines and passed through final test and touch-up to packaging and shipping. Even shipping cartons are delivered by conveyor from receiving to packing. All material movements have, as far as possible, been mechanized to spot parts where needed and when needed without tying up manpower.

Locates Grounds in Shielded Room

ENGINEERS that build screened rooms often discover a fault or ground between the inner and

(Continued on p 148)

FM SIGNAL GENERATOR

Type 202-B 54-216 mc.

Additional coverage from 0.4—25 mc. with accessory UNIVERTER Type 203-B

Shown above is an interior view of the 202-B Signal Generator RF assembly with shield cover removed. Heavy aluminum castings form the mounting base of this RF unit resulting in a compact and highly rigid structure. Girder type condenser frame construction, multiple rotor shaft grounding contacts, and welded interstage shield plates are but a few of the many design features of this unit which give added circuit stability.

Designed to meet the exacting requirements set forth by leading FM and television engineers throughout the country, the 202-B FM Signal Generator has found widespread acceptance as the essential laboratory instrument for receiver development and research work.

Frequency coverage from 54 to 216 megacycles is provided in two ranges, 54 to 108 megacycles and 108 to 216 megacycles. A front panel modulation meter having two deviation scales, 0-80 kilocycles and 0-240 kilocycles, permits accurate modulation settings to be made.

Although fundamentally an FM instrument, amplitude modulation from zero to 50%, with meter calibrations at 30% and 50%, has been incorporated. This AM feature offers increased versatility and provides a means by which simultaneous frequency and amplitude modulation may be obtained through the use of an external audio oscillator.

The internal AF oscillator has eight modulation frequencies ranging from 50 cycles to 15 kilocycles, any one of which may be conveniently selected by a rotary type switch for either amplitude or frequency modulation.

The calibrated piston type attenuator has a voltage range of from 0.1 microvolt to 0.2 volt and is standardized by means of a front panel output monitor meter.

The output impedance of the instrument, at the terminals of the R.F. output cable, is 26.5 ohms.

AVAILABLE AS AN ACCESSORY

is the 203-B Univerter, a unity gain frequency converter which, in combination with the 202-B instrument, provides the additional coverage of commonly used intermediate and radio frequencies.

R.F. Range: 0.4 mc. to 25 mc.

R.F. Increment Dial: ±250 kc. in 10 kc. increments.

R.F. Output: 0.1 microvolt to 0.1 volt. Also approximately 2 volts maximum (uncalibrated).

UNIVERTER
Type 203-B

For further information write for Catalog E

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THE ELECTRON ART

Edited by FRANK ROCKETT

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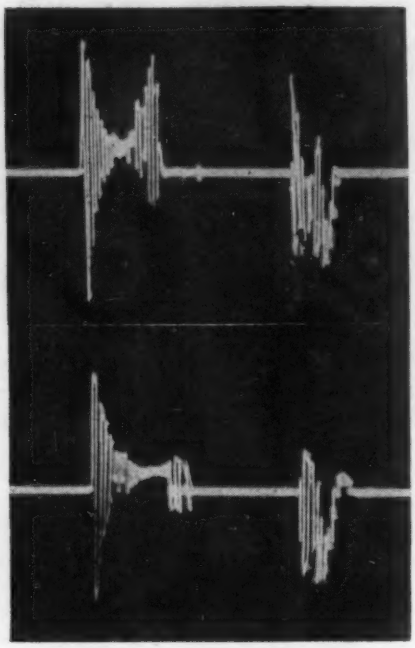
Diagnosing Engine Trouble

AIRCRAFT internal combustion engines are subject to failure from various causes. To determine and isolate the cause of engine troubles so that air liners can be serviced quickly, engineers of Sperry Gyroscope Co. have developed equipment for analysing engine operation. The analyzer, which can be installed on the ship with indicators at the flight engineer's position, includes vibration, knock, and ignition data.

Ignition is observed by means of a three-inch cathode-ray oscilloscope, the accompanying figure showing two typical traces. The vertical deflection plates are connected across the primary of the high-voltage transformer. A three-phase generator is driven by the engine shaft to produce the sweep, which can be used to display all plug voltages in order across the screen, or can be expanded and phased to display only one preselected plug voltage. The trace indicates actually the voltage across a network consisting of transformer, commutator, and spark plug, but effects of each component can be recognized. In addition to being useful in checking engine operation and locating faults, the equipment is being applied to studies of engine design and fuel technology.

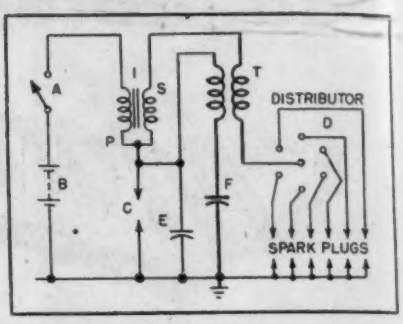


In both traces, the lefthand fluctuations are from the spark. Upper trace shows normal operation; lower trace shows effect of fouled gap

H-F Automobile Ignition

EFFECTIVENESS of spark ignition in automobiles can be increased by combining high-frequency oscillations with conventional heat sparks. Engineers of Tucker Corp. (Chicago, Ill.) have found that h-f spark emanation at the plugs is such that ionization of the gases during combustion is enhanced, and maximum engine power is produced with a gas-air mixture ratio approaching 16 to 1, whereas normal ignition produces maximum power with a mixture ratio of about 12.5 to 1.

The circuit used to product h-f sparks is shown in the accompanying drawing. A secondary capacitor F and Tesla coil T in the secondary circuit of the high-voltage transformer produce oscillation. Continuance of spark across the plug has been increased to about 35 deg of crankshaft rotation. Other circuits have been suggested (ELECTRONICS, p 180 July 1947) but the one illustrated here has given convincing practical results, and in fact, because instrumentation capable of oscillographic presentation could not be located, the h-f ignition has been evaluated on automotive performance rather than electrical criteria.



Heavy lines show additions of the Holthouse circuit to the conventional automobile ignition system

Optimum Parameter for Gas Tube Voltage Regulators

BY WALTER R. BERG
Research Assistant
Engineering Research
Ordnance Research Laboratory
The Pennsylvania State College

CIRCUIT CONSTANTS of the familiar gas tube voltage regulator can be adjusted to give a maximum possible regulation. This analysis is to determine the optimum conditions. The straight line current-voltage characteristic shown in Fig. 1A of neon gas tube voltage regulators such as the 991 and VR-75 makes a simple mathematical analysis possible. In the use of regulators that

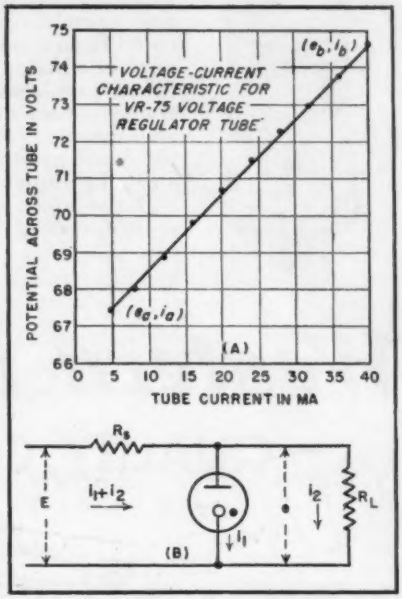


FIG. 1—If characteristic of gas tube is a straight line (A), its regulating action in a circuit (B) can be analysed

Table I—Measured Regulation

E	R_L	R_s	e	ΔE, change in input voltage	Δe, change in output voltage
VOLTS	OHMS	OHMS	VOLTS	VOLTS	VOLTS
145	∞	15,500	67.40	20	0.25
165	∞	15,500	67.65		
230	∞	32,500	67.40	20	0.15
250	∞	32,500	67.55		
230	3,000	5,850	67.40	20	0.60
250	3,000	5,850	68.00		

contain gases other than neon (VR-90, VR-105, VR-150) the voltage-current curve cannot be assumed to be a straight line; however, the general choice of circuit constants as derived in the following analysis holds for all types of gas tube voltage regulators.

The equation of the characteristics line is

$$e = ai_1 + b \tag{1}$$

where $$a = \frac{e_b - e_a}{i_b - i_a} \tag{2}$$

and $$b = e_a - ai_a \tag{3}$$

Figure 1B represents a typical gas tube voltage regulator circuit. In it

$$E = (i_1 + i_2)\,R_s + e \tag{4}$$

where R_s is the resistance of the current limiting resistor commonly used with stabilizer tubes. Also

$$e = R_L i_2 = ai_1 + b \tag{5}$$

$$\therefore i_1 = \frac{e - b}{a} \tag{6}$$

$$i_2 = \frac{e}{R_L} \tag{7}$$

Rewriting Eq. 4 gives

$$E = \left(\frac{e - b}{a} + \frac{e}{R_L}\right) R_s + e \tag{8}$$

or

$$e = \frac{aR_L E + bR_L R_s}{R_L R_s + aR_s + aR_L} \tag{9}$$

Equation 9 is the expression for the regulated voltage as a function of the supply voltage and the circuit parameters.

Differentiating Eq. 9 gives

$$\frac{de}{dE} = \frac{aR_L}{R_L(R_s + a) + aR_s} \tag{10}$$

Substituting in Eq. 9 and 10 gives

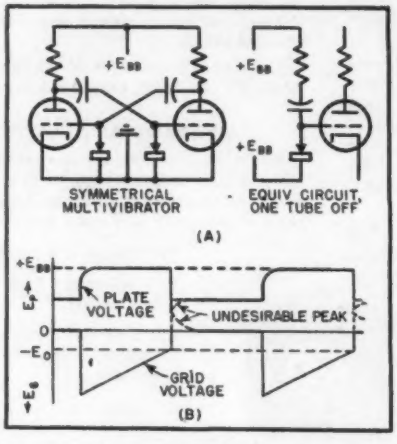
$$\frac{de}{dE} = \frac{ea}{aE + bR_s} \tag{11}$$

For the best regulation de—dE should be made as small as possible; for perfect regulation de—dE should equal zero. In the design of voltage regulator circuits e and a should be made small and b, E, and R_s should be made as large as possible. An analysis of Fig. 1B shows that R_s can be made larger if the value of R_L is increased. In other words, the regulation becomes better as the load current is decreased. In adjusting the circuit constants for maximum regulation it should be remembered that the above mathematical analysis holds only over the working range of the gas tube used. Table I shows the results of tests on the VR-75 tube of Fig. 1A used in the circuit of Fig. 1B.

Variable Time Constant

BY THRACY PETRIDES
New York City, N. Y.

DIODE CRYSTALS can be used as variable time constant circuit parameters. One application illustrating their employment and advantage is to a multivibrator. Figure 1A shows a multivibrator employing typical diode crystals as grid resistors. Where the negative voltage developed at the grid of the circuit is to be used, the positive peak due to grid current can be annoying. Using the diode crystals as grid resistors provides a variable time constant allowing the charging time of the coupling capacitor to be negligible compared to the discharging time. Thus during the time that the grid is tending to be positive, the diode resistance to the charging current is only about 100 ohms as compared to about 1,000 ohms during the rest of the cycle. Figure 1B compares the waveshapes obtained with and without the diodes showing their utility.



Crystal diodes, either alone or in parallel with grid resistors, prevent undesirable overshoot of multivibrator voltages

High Gain D-C Amplifier

BY W. G. SHEPARD
Calibration Engineer
Boeing Aircraft Co.
Seattle, Wash.

UNBALANCE resulting from shifting grid bias is eliminated by a parallel balanced directly coupled amplifier that has high gain, low drift, flat response from 0 to 50,000 cps, and negligible phase shift to 20,000 cps.

Counteracting Unbalance

Figure 1 shows several directly coupled amplifiers. The amplifier in Fig. 1A is of the push-pull type in which the signal is of equal amplitude but opposite phase in the two channels. Because drift voltage is in phase in each channel it does not add to the signal. Common cathode resistors in each stage tend to equalize the signal in each channel. When several stages are cascaded to give very high amplification, adjustments on any one stage seriously disturb other stages by affecting the bleeder current common to all stages. To obtain amplifier stability, these interrelating biases need to be eliminated.

In a circuit such as that of Fig. 1B where individual batteries are used to furnish the voltage drop between the plate of one tube and the grid of the next, any drift voltage in a stage appears equally on the grids of the next stage and therefore does not interfere with the signal. However, the drift does change grid biases of subsequent stages. As this change in grid bias is amplified by subsequent stages, it may reach proportions that shift the bias of final stages

(continued on p 174)

ALSIMAG technical ceramic insulators CUSTOM MADE FOR YOUR REQUIREMENTS

AlSiMag versatility is illustrated by these AlSiMag inserts for electronic tubes

The insulation requirements of electronic tubes vary with the function and design of the tube. Factors of primary importance are: Resistance to extreme heat shock without cracking and without reduction in strength; resistance to formation of electrical conduction paths; long life and strength even in tubes operated at relatively high temperatures. They must also be readily degassed and uniform in quality and dimension.

There is an AlSiMag technical ceramic composition with the physical characteristics suited to almost any electronic tube insulator or to any product requiring electrical insulation. That composition can be custom made in the size and shape which best meets your requirements. Most designs can be produced in quantities quickly and at low cost by die pressing. If you will send us your blue prints and technical data, we will be glad to outline the facts about AlSiMag Custom Made Technical Ceramics as they apply to your product.

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NEWARK, N. J., 671 Broad St., Tel: Mitchell 2-8159 • CHICAGO, 9 S. Clinton St., Tel: Central 1721 • SAN FRANCISCO, 163 2nd. St., Tel: Douglas 2464 • LOS ANGELES, 324 N. San Pedro St., Tel: Mutual 9076

NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, packaged units, allied products; new tubes. Catalogs and manufacturers' publications reviewed.

Mismatches can be immediately observed and measured in transmission lines, antennas, and coupling impedances. A descriptive circular is available.

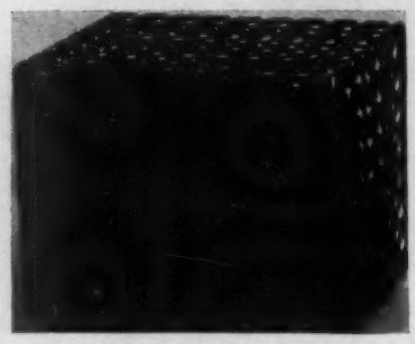
Instrument Pointer Pickup (1)

FAIRCHILD CAMERA & INSTRUMENT CORP., 88-06 Van Wyck Blvd., Jamaica 1, N. Y. The No Torque pickup replaces the covering glass window on the aircraft or industrial instrument to be read at a distance, and a small permanent magnet is then mounted on the indicator

shaft. There is no mechanical connection between pickup and instrument. Indication is obtained by the phase of the magnetic couple between the stationary magnetic field of the instrument pointer and the rotating field of the instrument pickup. A piezoelectric crystal is used to convert this mechanical couple into an electrical voltage. Phase angle is a function of the indicator pointer position.

Equalizer (2)

A. F. SCHMUCKLER & CO., 338 East 23rd St., New York 10, N. Y. The Afgsco equalizer 200X-1B is a small general purpose device for use where the nominal level is minus 10 db to 0 db. It can be incorporated in a console or used with relay rack mounting. It introduces no insertion loss or change in gain



at 1,000 cycles for any setting of the controls. It equalizes at 50 and 7000 cycles. Available in steps of 3 db from minus 15 to plus 15 db, when the position of both high and low controls is zero, its transmission is substantially flat from 50 to 15,000 cycles.

Reflection Meter (3)

KAY ELECTRIC CO., 34 Marshall St., Newark 2, N. J. The Mega-Match measures reflected energy over a frequency range from 10 to 250 megacycles or higher, giving a visual display for bands as wide as 30 megacycles. A precision wavemeter is incorporated in the device.

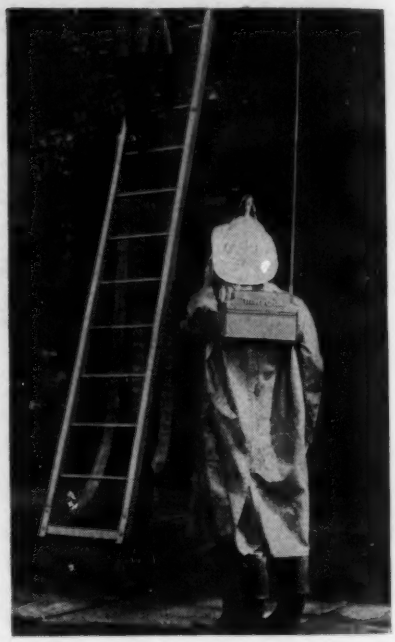
USING THE NUMBERS

Readers desiring further details concerning any item listed in the New Products department can obtain the information by using the cards furnished as a stiff, colored insert elsewhere in this department.

Place the number (appearing to the right of the heading) of one item in which you are interested in a circle and then fill out the balance of the card according to directions appearing on the colored sheet. Unnumbered items listed at the end should be procured direct from the manufacturer or publisher upon payment of the fee noted.

Talkie (4)

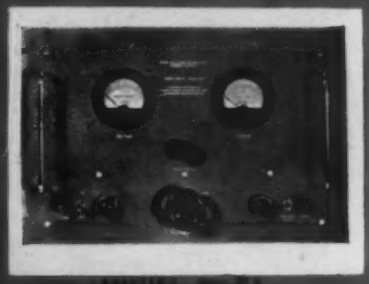
MOTOROLA INC., 4545 Augusta Blvd., Chicago 51, Ill. A handie-talkie operating in the 25 to 44 megacycle band weighs 7 pounds and can be used for reliable communi-



cation up to two miles. The frequency-modulated transmitter and the receiver use 18 tubes and the equipment operates from standard dry batteries.

Shutter Speed Meter (5)

HICKOK ELECTRICAL INSTRUMENT CO., 10527 Dupont Ave., Cleveland 8, Ohio. An electronic instrument to measure the shutter speed of any camera consists of a light source and photosensitive element connected to a meter that reads shut-



Regulated Power Supplies

MODEL 106-PA

Characteristics:

D.C. Voltage Range . . . 200-300V., 140 Ma.
A.C. Fil. Power . . . . . (2) 6.3V., 5 amps.
Ripple Content . . . . . 1/10 of 1%
A.C. Input . . . . . 115V., 50/60 cycles
Size . . . . . 5" x 19" x 9" deep

Output remains constant within 1%, even though line voltage varies between 95—130 volts. Price $225 (f. o. b. Cambridge, Mass.)

MODEL 206-PA

Characteristics:

D.C. Voltage Range . . 500-700V., 250 Ma.
700-1000V.,200 Ma.
Ripple Content . . . . . .05 of 1%
A.C. Input . . . . . 115V., 50/60 cycles
Size . . . . . 12¼"x19"x13" deep

Output is constant from no load to full load of each range within 1%.

Interlocking relay protection at all voltages insures safe operation. Time delay for high voltage circuit applications prevents tube damage. Price $490 (f. o. b. Cambridge, Mass.)

MODEL 207-PA

Characteristics:

D.C. Voltage Range . . 0-3500V., 1 amp. positive or negative grounding
A.C. Input . . . . . 220V., 50/60 cycles (Variac Control)
Overload Relay . . . . . Adj. 0.6—1 amp.
Size . . . . . 26⅛"x32"x36" deep

Meters on front panel indicate line voltage, output voltage, and output current.

Power supply is mounted on casters for portability Access doors provided with interlock safety switches.

MODEL 306-PA

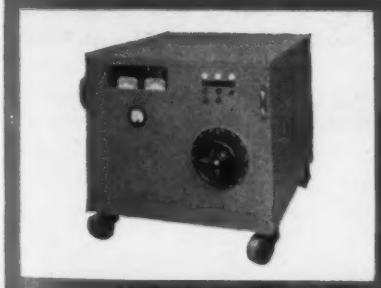
Characteristics:

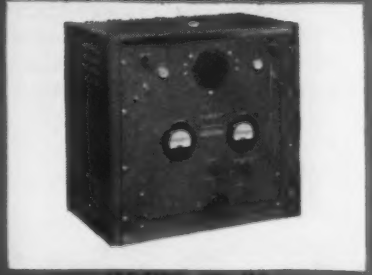
D.C. Voltage Range . . 300-750V., 30 Ma.
750-1800V., 30 Ma.
1800-3600V., 30Ma.
Ripple Content 300-750V., 0.01%
750-1800V. } 0.1%
1800-3600V. }
A.C. Input . . . . . 115V., 50/60 cycles
Size . . . . . 17½"x19"x13" deep

Regulation control is provided for adjustment to perfect load regulation, or to provide over-regulation, if desired.

Safety devices are incorporated to protect operating personnel. Meters indicate line voltage, output voltage, and output current.

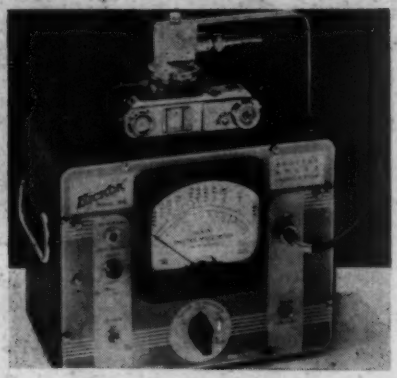
For Every Purpose





HAR-CAM

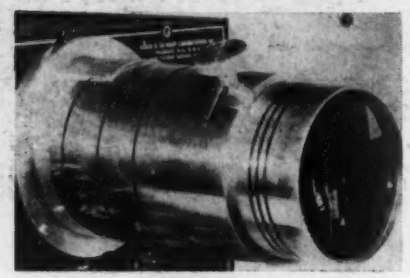
HARVEY RADIO LABORATORIES, INC.
439 CONCORD AVENUE • CAMBRIDGE 38, MASSACHUSETTS



ter timing directly in fractions of a second. Model 166 tells the story quickly.

Oscilloscope Projection Lens (6)

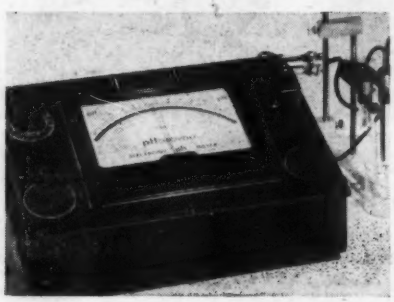
ALLEN B. DUMONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J. Large-screen oscillograms can be obtained with the type 2088 projection lens on oscilloscopes employ-



ing the type 5RP-A high-voltage cathode-ray tubes. A pattern can be projected to distances beyond 8 feet.

pH Meter (7)

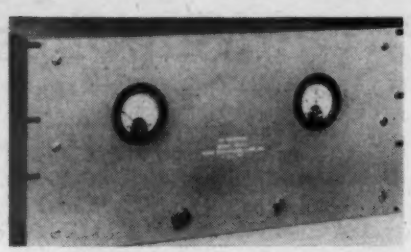
PHOTOVOLT CORP., 95 Madison Ave., New York 16, N. Y. The new model 100 pH checker uses a meter that covers the complete pH range on a single dial. A wide-range temperature control simplifies use of the equipment which requires no batteries. The model 105 unit includes



a carrying handle and hood. The equipment is described in a single page sheet.

Relay Receiver (8)

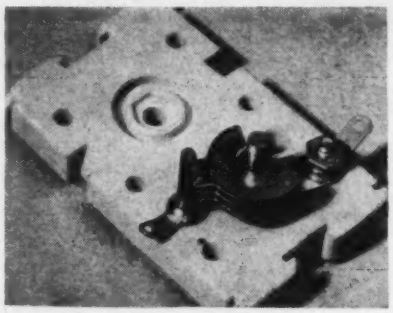
RADIO ENGINEERING LABS., INC., 35-54 36th St., Long Island City 1, N. Y. Type 670L relay receiver is essentially a custom built job for broadcasters interested in receiv-



ing only one frequency. The equipment has been used for f-m broadcast relay service in the 88- to 108-megacycle band. Low distortion, high fidelity, and crystal control are a few of the main features of the equipment.

Small Air Capacitor (9)

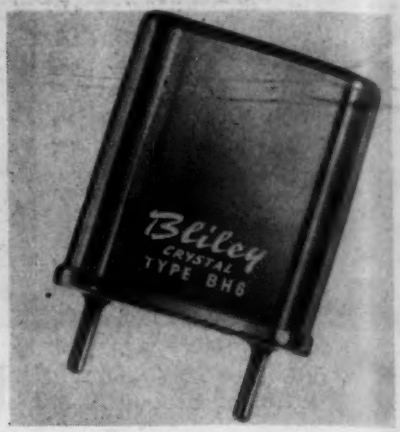
HAMMARLUND MFG. CO., INC., 460 West 34th St., New York 1, N. Y. The type 533 trimmer is a precision capacitor of not more than 15 microfarads. It uses for its base the



insulated support of any component in the chassis at the physical point it is needed. Available only to manufacturers, it is sold mounted on bases supplied or as rotor and stator assemblies together with parts required for installation.

VHF Crystal (10)

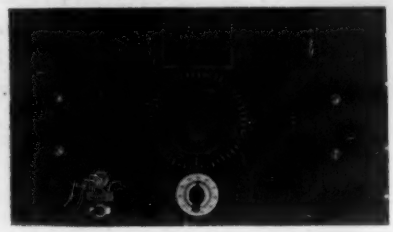
BLILEY ELECTRIC CO., Erie, Pa. Type BH-6 vhf crystal can be used



in the range between 15 and 100 megacycles. Special circuits are employed to select the third, fifth, and seventh harmonics of the crystal fundamental mode. Crystals are lapped to 0.004 inch, silver plated, and clamped rigidly between ceramic rings.

Oven Temperature Control (11)

W. S. MACDONALD CO., 33 University Road, Cambridge 38, Mass. A proportioning electronic tempera-



ture controller is available that maintains the temperature of electrically heated ovens within less than 0.1 degree at temperatures up to 1,200 F. Power flow to the oven is continuous rather than in on-off cycles. A large vernier type dial allows quick and accurate selection of desired temperature. Power is not throttled until the furnace reaches a point within 15 degrees of the preset value, thus speeding the initial heating.

Coax Relay (12)

ADVANCE ELECTRIC AND RELAY CO., 1260 West 2nd St., Los Angeles, Calif. The Series 7200 a-c and 8200 d-c relays are designed for spdt switching of 50-ohm coaxial

(continued on p 192)

YOU CAN BUY THE SKILL THAT MADE THESE GEARS

The same skill with which we fabricate Small Gears for so many of America's most particular users, is also available for *you*. Get started now depending upon this one BIG source for all of the Small Gears you need. Here, you'll enjoy the advantage of all the large, highly specialized facilities developed thru a quarter century of concentrating on the manufacture of finer Small Gears exclusively.

If you need production runs of Fractional Horsepower Gears that perform more smoothly and accurately, that measure up to highest *uniform* standards of quality and precision, by all means discuss your requirements with a G.S. Engineer! Possibly he may suggest a better design, a more practical material, a method of production that will result in better gears, at moderate cost. Will you write or telephone us *today*?

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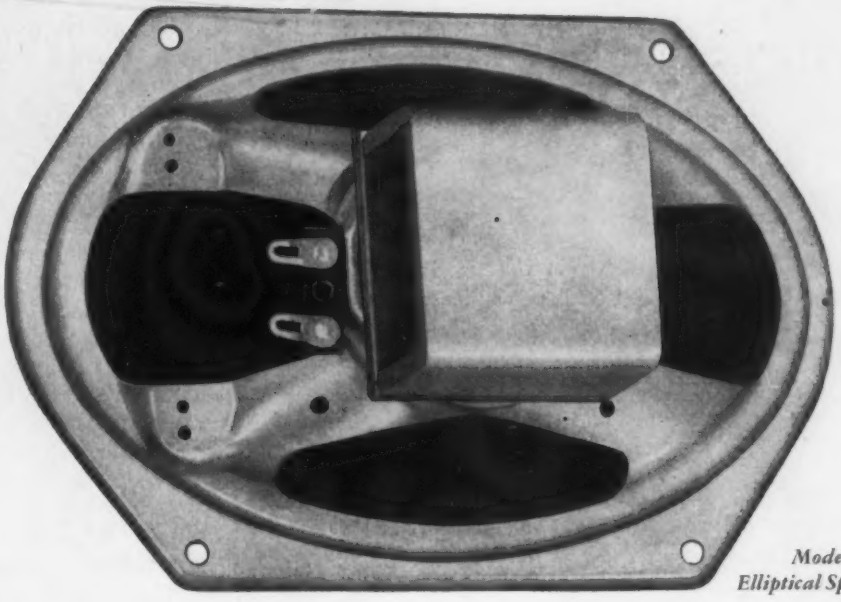


Model 57B2226, 5" x 7"
Elliptical Speaker shown above

Magnavox presents...

a new 5" x 7" Elliptical Speaker

NOW The Magnavox Company, pioneer in the production of elliptical speakers, offers you another important new addition to its family of famous component parts—Model 57B2226, 5" x 7" Elliptical Speaker.

This model is immediately available in electrodynamic or permanent magnet design, in various field and magnet sizes to meet any requirement. Your inquiries are invited.

The Elliptical Speaker offers decided advantages in design and performance for a wide variety of applications. Where space is at a premium (especially height), or when a certain sound pattern is desired, the popular oval speaker has proven itself to be the answer.

Over 100 different speaker models are made to supply every production need. Capacitors and other component parts are "tailor-made" to the individual manufacturer's requirements. In your planning, be sure to consult with loud speaker headquarters. The Magnavox Company, Components Division, Fort Wayne 4, Indiana.

Magnavox

has served the radio industry for over 32 years

SPEAKERS · CAPACITORS · SOLENOIDS · ELECTRONIC EQUIPMENT

NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

Status of civilian GCA; first issue of Nucleonics; program of Chicago Electronics Conference; Soviet television plans

Electronic Computing Service

AN INSTITUTE of Numerical Analysis is to be established at the University of California in Los Angeles, utilizing electronic apparatus to do research in applied mathematics and provide an ultra-speed computing service for the West.

The Institute will be a unit of the National Applied Mathematics Laboratories now being organized at the National Bureau of Standards. It will have two basic functions: (1) research and training in applied mathematics, with particular emphasis on the efficient exploitation and development of high-speed electronic computing machines; (2) the provision of an expert computing service for groups located in the West.

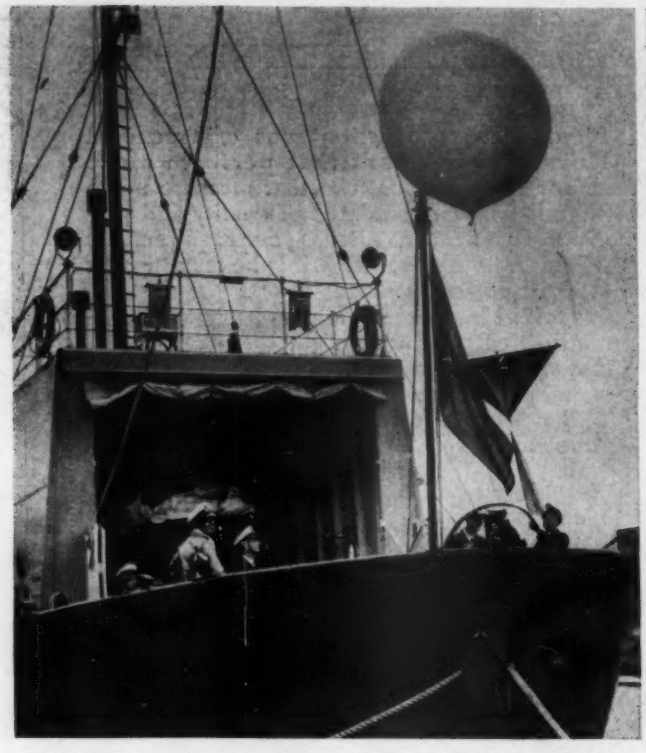
One of the giant high-speed electronic computing machines, now under development by the Bureau of Standards, will be installed at the Institute when completed. These computers will solve problems in minutes that now take days to work out, and will solve in days problems that are now out of the reach of scientists. Design specifications call for high memory capacity and automatically sequenced mathematical operations from start to finish.

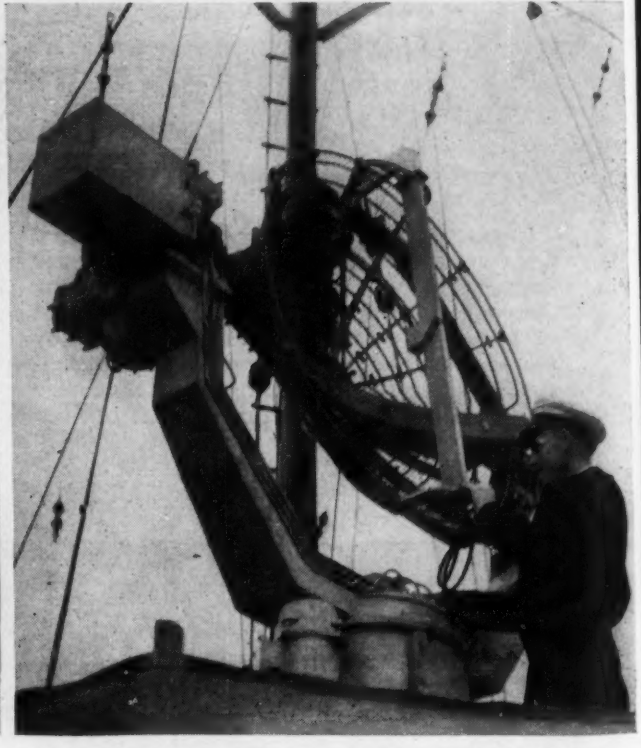
The Institute has two primary functions. The first is research in applied mathematics aimed at developing methods of analysis which will extend the use of the high-speed electronic computers. The second is to act as a service group for Western industries, research institutions, and government agencies.

Proposed Changes in Television Allocations

SHARING of television channels with other radio services having proved

TRACKING RADIOSONDE WITH RADAR ON WEATHER SHIP





LEFT: Releasing weather balloon from which is suspended a triangular metal rawin reflector for observing winds aloft by tracking with radar. A conventional radiosonde is carried below the reflector for transmitting temperature, pressure, and humidity data to this British weather ship "Weather Observer." RIGHT: Radar antenna used on ship for tracking the weather balloons during their ascent into the stratosphere. This is the first weather ship to be outfitted under a recent agreement wherein 10 nations will provide 13 such ships for stations in various parts of the Atlantic to provide meteorological data and navigational aids for aircraft, as well as assist in aircraft rescue when necessary. Every few hours each ship will radio data to its base, from which the information will be pooled and made available to airline operators, weather-predicting agencies and similar services

INCREASED PRODUCTION to meet increased demand permits NEW LOW PRICES for FRANKLIN AIRLOOPS*

* AIRLOOPS . . . *back panel and loop antenna in one unit*

More and more manufacturers of receiving sets are adopting **AIRLOOPS** as standard for their loop antenna and cabinet back requirements . . . this increase in demand permits manufacturing economies which are going right back to **AIRLOOP** users, in the form of NEW LOW PRICES . . . competitively **AIRLOOPS** are the lowest cost loop antenna and cabinet back and more important **AIRLOOPS** incorporate many superior features which in themselves improve set performance . . . no set builder can afford to overlook the significance of the **AIRLOOP**.

. . . FRANKLIN AIRLOOPS are flat sheets of copper die-stamped into perfect super sensitive loops . . . are air dielectric throughout . . . are lower in cost . . . are back panel and loop in one unit . . . have high uniform "Q" over entire band . . . have low distributed capacity . . . have 27% greater effective loop area . . . have electrical and mechanical stability . . . increase set sensitivity . . . eliminate individual loop adjustment . . . eliminate haywire.

FRANKLIN *Airloop* **CORPORATION**

43-20 — 34th ST., LONG ISLAND CITY 1, N. Y.

MEETINGS

SEPT. 24-26: West Coast IRE Convention, Palace Hotel, San Francisco, Calif., Prof. Karl Spangenburg, general chairman, Stanford University, Palo Alto, Calif.

SEPT. 26-28: Third annual Electronics Trade Show, Hotel Whitcomb, San Francisco, sponsored by West Coast Electronic Manufacturers' Association, W. Noel Eldred, secretary, care of Hewlett-Packard Co., Palo Alto, Calif.

SEPT. 26-28: Hudson Division ARRL Convention, Convention Hall, Asbury Park, N. J.; technical papers and exhibits of electronic equipment for radio amateurs.

SEPT. 29-OCT. 2: Annual meeting, International Municipal Signal Association, Inc., Pantlind Hotel, Grand Rapids, Michigan; technical papers and exhibits of police and fire radio equipment.

SEPT. 30-OCT. 11: National Radio Exhibition, Olympia Hall, London, sponsored by British Radio Industry Council and featuring new British radio, electronic control, radar, and television equipment.

OCT. 20-22: Joint meeting of International Scientific Radio Union and IRE, Washington, D. C.; technical papers.

OCT. 20-24: SMPE Theater Engineering Conference, Hotel Pennsylvania, New York.

OCT. 23-25: Annual Meeting, Optical Society of America, Netherland Plaza, Cincinnati, Ohio; symposium on microwave optics.

NOV. 3-5: National Electronics Conference, Edgewater Beach Hotel, Chicago.

NOV. 3-7: AIEE Midwest General Meeting, Chicago, Ill.

NOV. 7-8: Conference on X-ray and Electron Diffraction, Mellon Institute of Industrial Research, Pittsburgh, Pa.

NOV. 17-19: Rochester Fall Meeting, Sheraton Hotel, Rochester, N. Y.; technical papers and exhibits.

NOV. 19-23: Television Exposition, Kiel Auditorium, St. Louis, Mo.; exhibits and telecasts.

MARCH 22-25: IRE Convention and Radio Engineering Show, Hotel Commodore and Grand Central Palace, New York City.

impracticable because of serious interference to television reception, the FCC proposes to abolish channel-sharing provisions. In order to accommodate the nongovernment fixed and mobile radio services for which provision was formerly made on a shared basis on television channels 1 through 5 and 9 through 13, the assignment of channel 1 (44-50 mc) is to be changed from television to nongovernment fixed and mobile. At the present time there is no television station operating on this channel and only one construction permit is outstanding.

The band 72-76 mc is to be limited to use by the 75-mc aeronautical marker beacons and to fixed circuits on an engineered basis with a view to avoiding adjacent-channel interference to television broadcasting. Radio stations presently authorized for this band would be permitted to continue for a five-year period.

An oral argument will be held before final action only if comments received before Sept. 15, 1947 appear to warrant holding such a hearing. If the proposed changes are adopted, the table of frequency allocations published in June 15, 1946 ELECTRONICS, p 82, will be modified as follows:

BAND IN MC	UNITED STATES
44-50	Nongovernment fixed & mobile
50-54	Amateur
54-60	Television broadcasting, channel 2
60-66	Television broadcasting, channel 3
66-72	Television broadcasting, channel 4
72-76	Nongovernment fixed
76-82	Television broadcasting, channel 5
82-88	Television broadcasting, channel 6
174-186	Government fixed & mobile
174-180	Television broadcasting, channel 7
180-186	Television broadcasting, channel 8
186-192	Television broadcasting, channel 9
192-198	Television broadcasting, channel 10
198-204	Television broadcasting, channel 11
204-210	Television broadcasting, channel 12
210-216	Television broadcasting, channel 13

Status of Civilian GCA

THE ARMY AIR FORCES has given CAA full title to the three ground controlled approach radar sets operated by the CAA on loan from the AAF at New York (LaGuardia Field), Washington, and Chicago. The CAA had requested appropriations for the purchase of these three sets and of 20 additional, but was given funds for purchase of only two sets.

As a further step toward full utilization of available funds for air safety, it has been agreed that CAA and the AAF will explore the possibility of joint procurement of improved GCA sets to be ordered by both agencies about January, 1948. It is hoped that in this way the CAA, with funds to purchase only two sets, can obtain the savings of mass production while specifying modifications which it may require for civil use.

With continued availability of the sets assured, CAA has inaugurated 24-hour GCA service at the three locations.

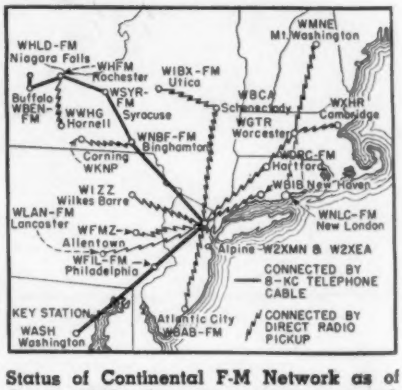
Earlier this year, the AAF had offered CAA a loan of 20 additional GCA sets, but in view of the elimination by Congress of funds requested for operating them, CAA has notified the Army that it is unable to accept this offer.

Narrow-Band F-M Authorized

USE OF narrow-band frequency modulation for radiotelephony by class A amateur radio operators in the bands 3,850-3,900 kc and 14,200-14,250 kc has been authorized by the FCC on an experimental basis until further order, but in no event beyond Aug. 1, 1948. In addition, the holder of any class of amateur radio operator license is authorized to use narrow-band f-m radiotelephony at any licensed amateur radio station on frequencies from 28.5 to 29 mc

(continued on p 240)

F-M NETWORK



Status of Continental F-M Network as of August 1947, when three programs a week were being carried by a total of 20 stations. 8 connected by AT&T lines equalized to over 8,000 cycles, and the remainder using direct radio pickup and rebroadcasting

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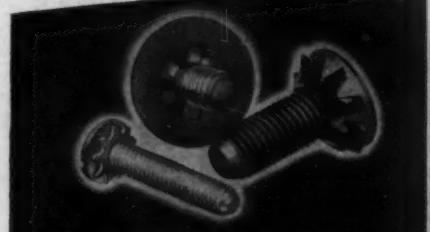
FOR SEMS WASHER SCREW ASSEMBLIES



Washer permanently fastened on, yet free to rotate. Easier, faster driving. No fumbled, lost or forgotten washers. Matching finish on both parts. Easier ordering and balanced inventories.

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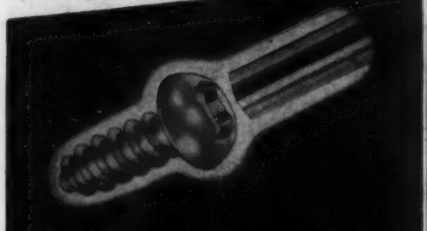

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TUBES AT WORK
(continued from p 134)

outer screens upon completion. The usual procedure is then to tear out the inner screen and rebuild it. One government laboratory reconstructed the inner screen three times before it was ground free.

At the Cook Research Laboratories in Chicago, a technique has been used for this purpose employing an oscilloscope, a solenoid exploring coil, and a 1-kva, 60-cycle, step-down transformer.

The low-voltage secondary of the transformer was connected with one terminal to the outer screen and one terminal to the inner screen. With its primary energized from the laboratory power circuit, approximately 100 amperes of current flowed from one screen to the other through the one or more faults. The solenoid exploring coil was connected to the vertical deflecting circuit of the oscilloscope and was moved along the

Reversal of polarity shown on the scope screen indicates location of faults in screening

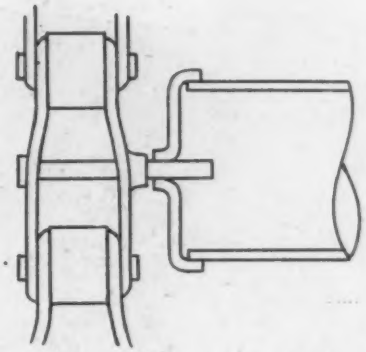
inside wall of the room, particularly along the wall-ceiling and wall-floor junctions.

While moving the coil, the operator could observe on the c-r tube the increase or decrease of signal produced by the magnetic field of the fault current flowing in the inner screen. As a fault was approached, the signal amplitude would build up and when going di-

Problems solved by Richardson...in Plastics

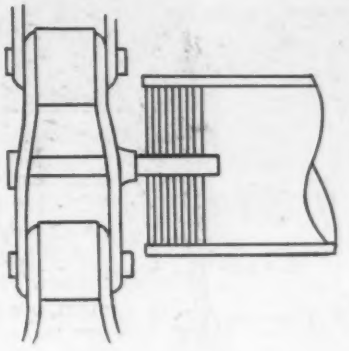
#3--NON-CORRODING BEARING ON POTATO WASHING MACHINE

PROBLEM: GALVANIZED ROLLERS MUST GENTLY MOVE AND ROTATE POTATOES THROUGH A WASHING OPERATION WITHOUT DAMAGE. ROLLER ASSEMBLY CONSISTED OF A TUBE WITH A STAMPED METAL CAP WELDED ON EACH END WHICH SERVED AS THE BEARING. WATER WAS ALWAYS PRESENT WHICH CORRODED BOTH CAP AND CONVEYOR PIN. CORROSION, PLUS THE METAL-TO-METAL CONTACT, RESULTED IN EXCESSIVE WEAR OF BOTH PARTS. THIS CAUSED MISALIGNMENT, CREATING A SLIDING ACTION OF THE ROLLER ON THE RAILS. THE FINAL RESULT WAS IMPROPER WASHING OF THE POTATOES AS WELL AS INCREASED POWER DEMANDS.



SOLUTION: THE STAMPED METAL CAP WAS REPLACED BY A DISC OF LAMINATED INSUROK, GRADE CG WHICH WAS PRESS-FITTED INTO THE ROLLER. RESULT . . .

(1) WELDING OPERATION ELIMINATED.
(2) INSUROK DISC GREATLY INCREASED THE BEARING AREA, GIVING BETTER SUPPORT TO THE ROLLER.
(3) FRICTION GREATLY REDUCED BECAUSE OF THE CHARACTERISTICS OF INSUROK GRADE CG.
(4) GREATLY LESSENED POWER LOAD
(5) WEAR ON CONVEYOR PIN AND BEARING PRACTICALLY ELIMINATED.
(6) THE ROLLERS ROTATE IN A PARALLEL PLANE, RESULTING IN A BETTER WASHING OPERATION.



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INSUROK is the family name of a great variety of laminated and molded plastic products produced by Richardson. Laminated INSUROK is available in sheets, rods, tubes, punched and machined parts, made with paper, fabric, glass, etc. Molded INSUROK products are made from Beetle, Bakelite, Plaskon, Tenite, Styron, Durez, Lucite, etc., by compression, injection and transfer molding.

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Thousands of secretaries have long exclaimed, "Oh! For a transcribing machine with *comfortable* headphones."

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Write Department AM for information and quotations. We'll be happy to show you how the TELEX Monoset can become part of your team for perfect hearing comfort wherever headphones are needed.

SPECIFICATIONS

Impedance: 2000 ohms—Part No. 2568
500 ohms—Part No. 2569
128 ohms—Part No. 2570

Sensitivity: 88 d.b. above .000204 dynes per square centimeter for 10 microwatt input.

HEARING AT ITS BEST
TELEX INC.
ELECTRO-ACOUSTIC DIVISION
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Minneapolis, Minn.

Canadian Distributors:
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rectly over the fault, the amplitude would go to zero and reappear with reversed polarity. In every case, the faults were found to be at the exact points where the polarity reversal took place. To prevent getting false indications of polarity reversal the operator had to take care not to rotate the exploring coil about any of its own axes as he moved it along.

General Purpose Portable Amplifier

By C. R. Smitley
Research Assistant
Ordnance Research Laboratory
The Pennsylvania State College
State College, Pa.

Small versatile amplifiers are commonly required in the laboratory or classroom in conducting various experiments or demonstrations. In filling this need, an amplifier system was developed to meet the following specifications: (1) Frequency range of 1kc to 100 kc; (2) Flat gain within 0.5 db over the above frequency range; (3) Voltage gain of 20 db or 40 db to be switch selected; (4) Equivalent input noise level less than 90 db below one volt; (5) Incorporation of high-impedance input stage to prevent loading of electronic circuits by the amplifier; (6) Operation from a 115-volt a-c line; (7) Shock mounting of the amplifier to reduce microphonics; (8) Small physical size and portable construction.

Amplifier Circuit

The schematic diagram of the amplifier appears in Fig. 1. Tubes V_1 and V_2 are 6SJ7's used as R-C coupled high gain voltage amplifiers. The R-C constants are so chosen that the gain-versus-frequency characteristic in the range 1 kc to 100 kc is constant within 0.5 db. The output of V_2 is applied to V_3, a 6SH7 cathode follower output tube. Tube V_4 is a 6SH7 connected as an auxiliary cathode follower to serve as an impedance transformer for use in making measurements across high-impedance circuits.

Rotary switch S_1 is used to change the gain of the amplifier or to connect the impedance trans-

YOUR PRODUCT, TOO

CAN BE RADIO NOISE-PROOFED WITH C-D *Quietones*

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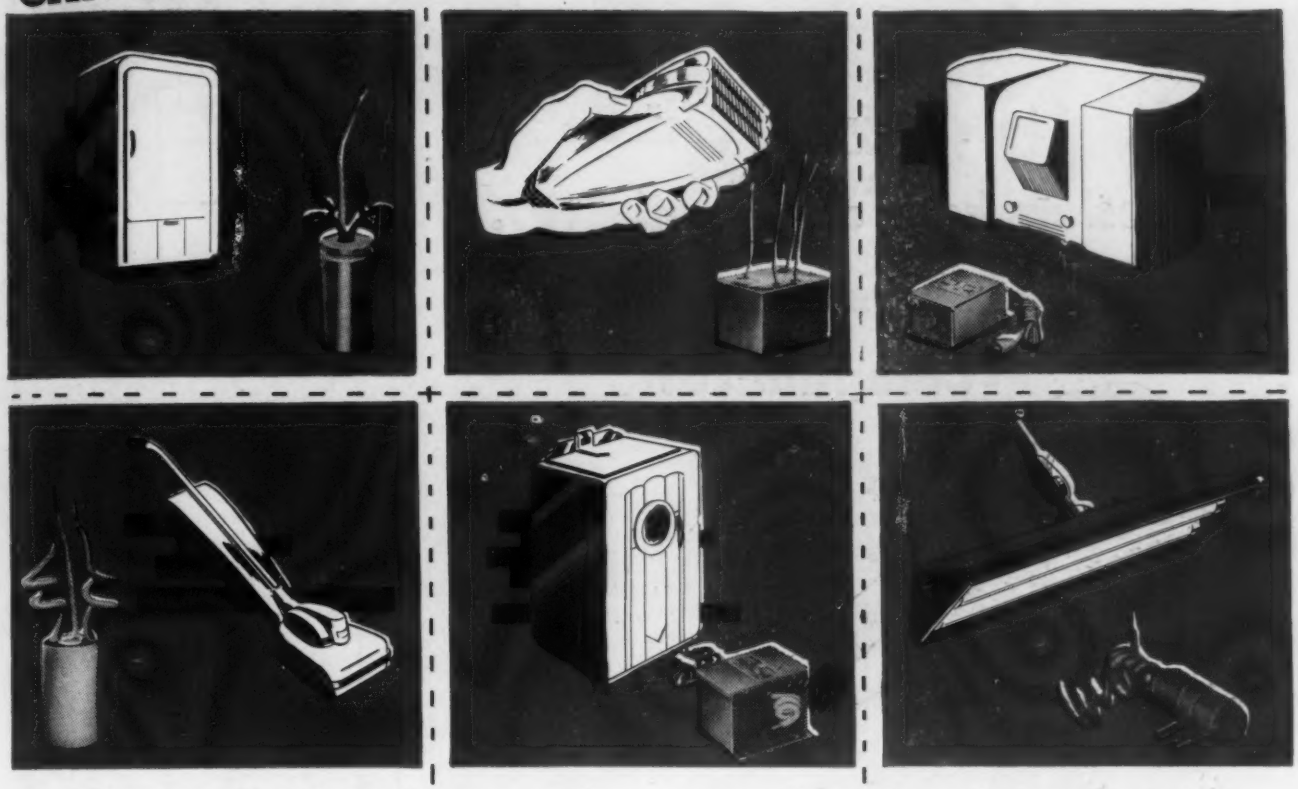
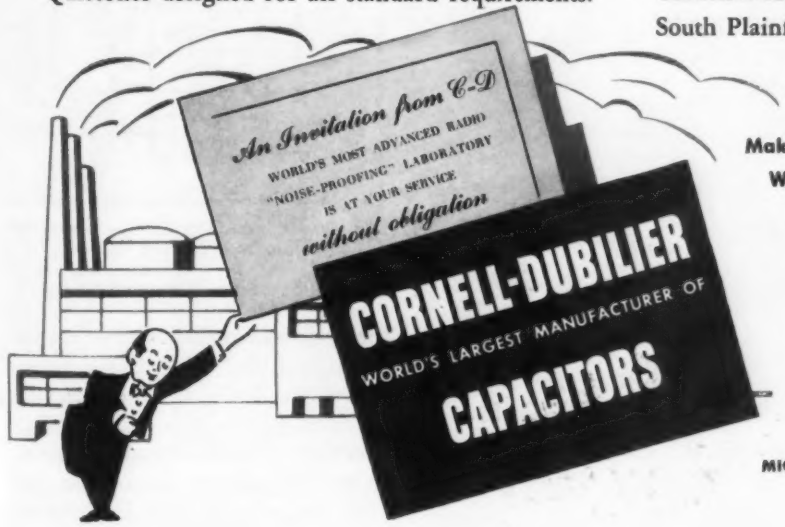


When we say Radio Noise-*Proofed*—we mean Radio Noise-*Proofed*. It's no trick at all to build a filter with high attenuation at 150 kc *or* 100 mc . . . but to build one which filters at 150 kc *and* 100 mc—*as well as all points in between*—is a horse of a different color. We know because we've done it. It is only one of hundreds of *available* types of C-D Quietones designed for all standard requirements.

Among these stock types there may be one which will bring the interference level of your product down to the level of a rabbit's bark. If not, we invite you to make full use of our Radio noise-proofing laboratory and our engineers for the development of a unit designed for your specific needs.

Your inquiries are cordially invited. Address: Cornell-Dubilier Electric Corporation, Dept. K-10, South Plainfield, N. J. Other large plants in New Bedford, Worcester and Brookline, Mass., and Providence, R. I.



Make Your Product More Saleable With C-D Quietone Radio Noise Filters and Spark Suppressors

1910 1947

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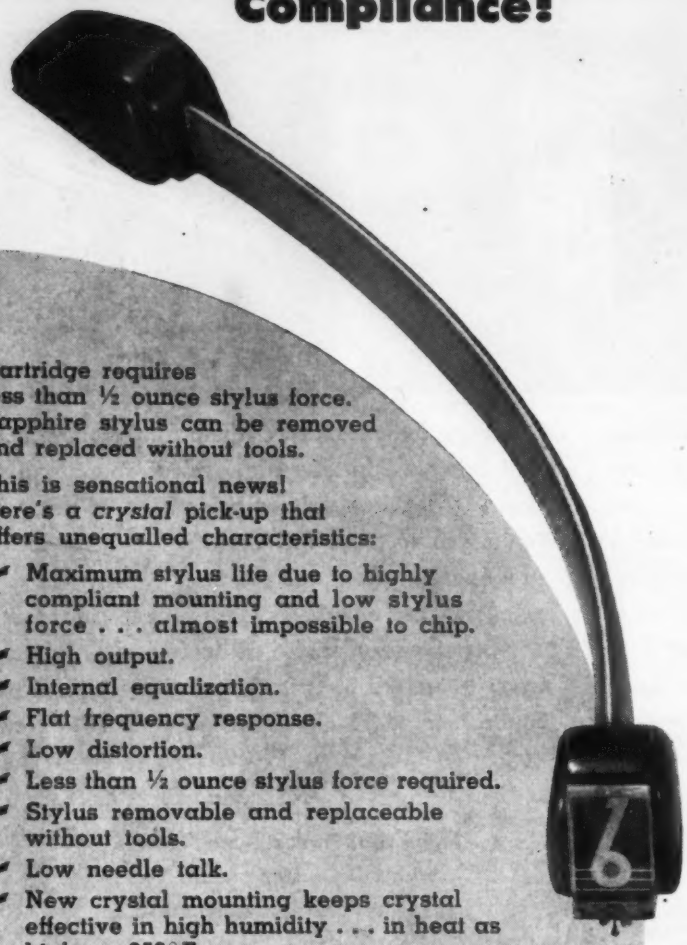
New Crystal Pickup resists heat and humidity... provides High-Stylus Compliance!



Cartridge requires less than ½ ounce stylus force. Sapphire stylus can be removed and replaced without tools.

This is sensational news! Here's a *crystal* pick-up that offers unequalled characteristics:

- Maximum stylus life due to highly compliant mounting and low stylus force . . . almost impossible to chip.
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- Low needle talk.
- New crystal mounting keeps crystal effective in high humidity . . . in heat as high as 250° F.
- Tests show cartridge unharmed after 15 minutes in boiling water.

For the complete story on this latest Brush development, write TODAY!

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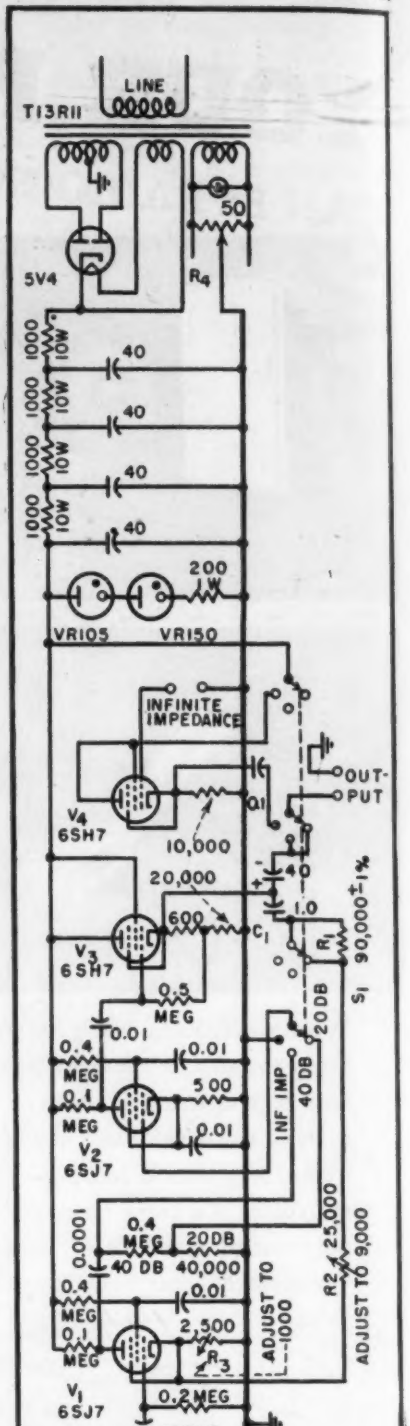
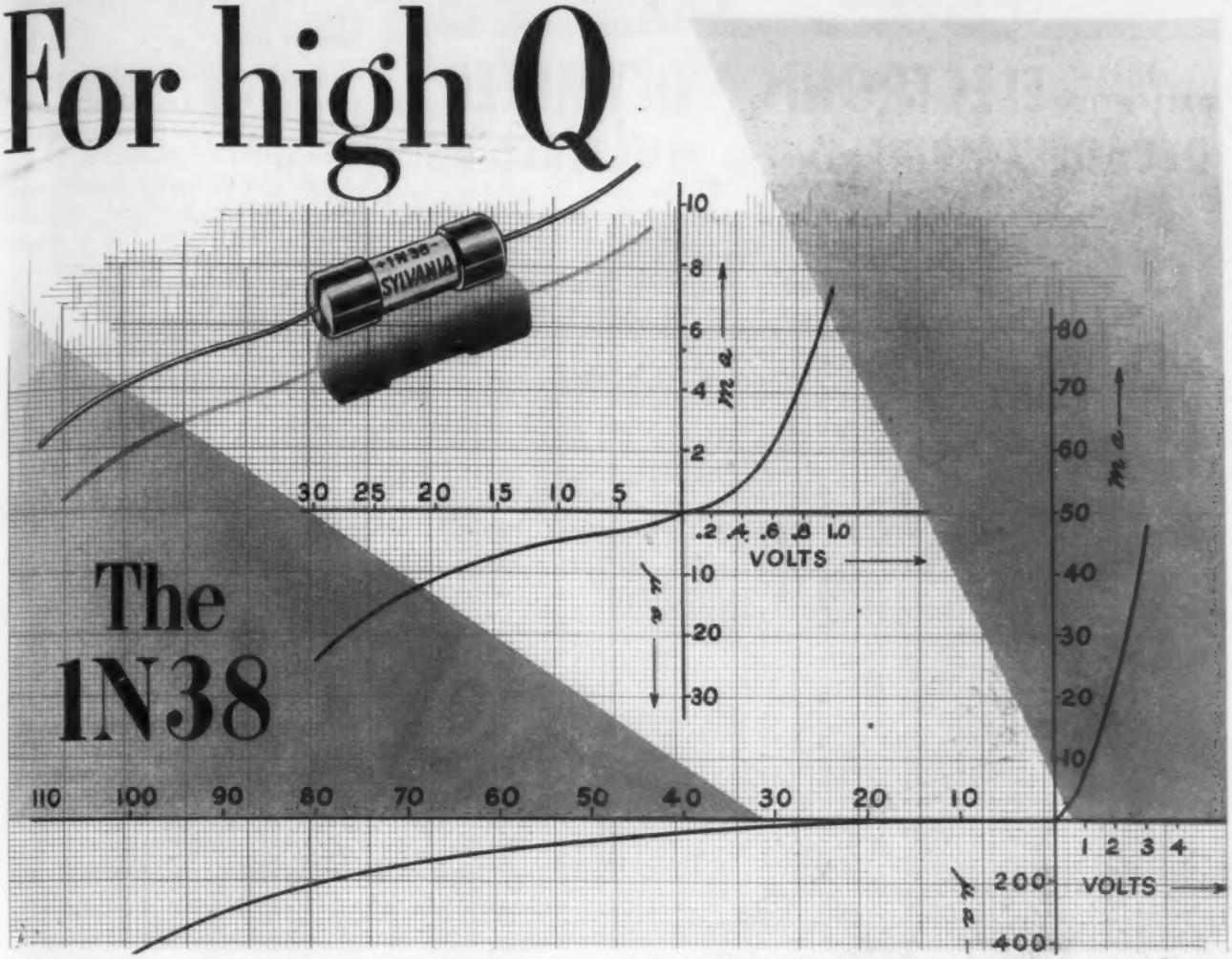


FIG. 1—The amplifier incorporates a two-position gain control, and auxiliary cathode follower for measurements across high impedance electronic circuits

forming cathode follower to the output terminals. With the switch in either the 20-db or 40-db position, the output of V_3 is connected to the output terminals; when the switch is in the infinite impedance position, the cathode of V_4 is connected

For high Q



The 1N38

- A megohm at −3 volts.
- .5 megohm at −1 volt.
- 2 megohms at −5 volts.
- .8 megohm at −2 volts.
- .35 megohm at −½ volt.
- 2 megohms at −18 volts.
- A megohm at −33 volts.
- .25 megohm at −100 volts.

The 6,000,000th crystal Sylvania made was a 1N38!

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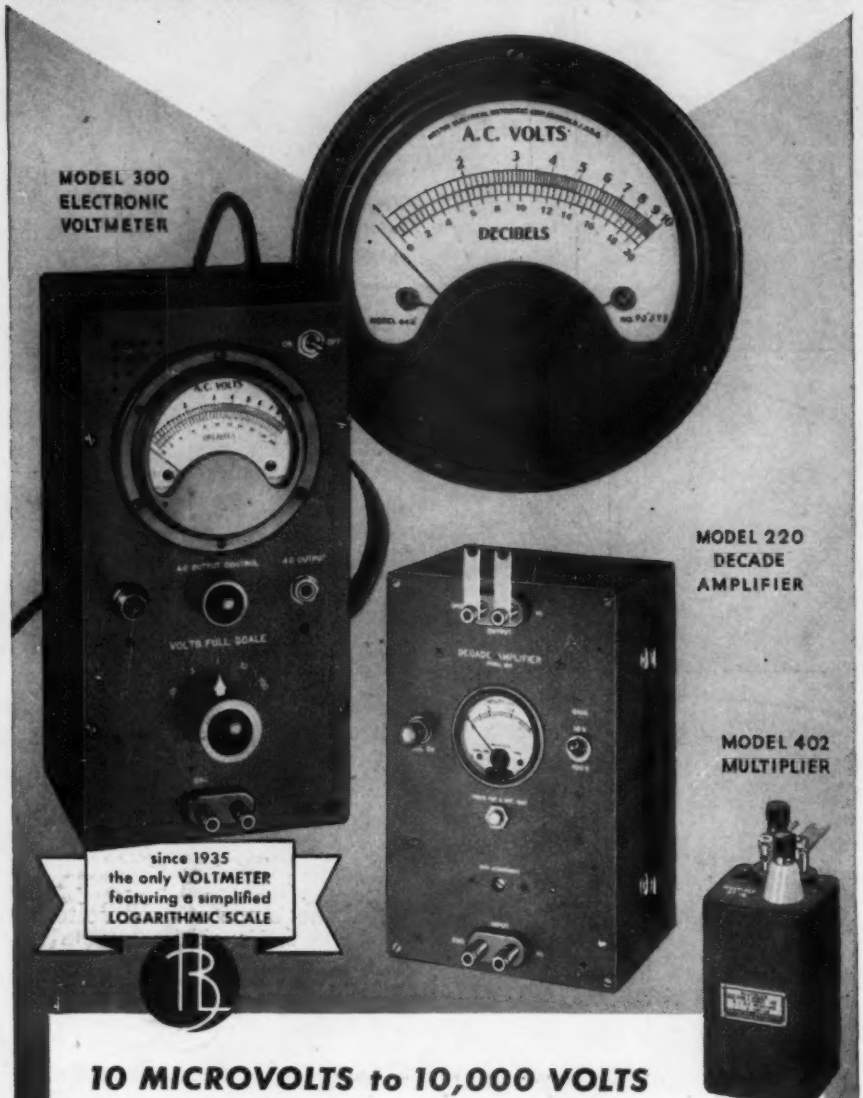
THE BALLANTINE ELECTRONIC VOLTMETER, DECADE AMPLIFIER AND MULTIPLIERS



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ONE BILLION TO ONE—This enormous range of AC voltages—is easily covered by the Model 300 Voltmeter, Model 220 Decade Amplifier and Model 402 Multipliers illustrated above. The accuracy is 2% at any point on the meter scale, over a frequency range of 10 cycles to 150 kilocycles. The Model 300 Voltmeter (AC operated) reads from .001 volt to 100 volts, the Model 220 Amplifier (battery operated) supplies accurately standardized gains of 10x and 100x and the Model 402 Multipliers extend the range of the voltmeter to 1,000 and 10,000 volts full scale.

Descriptive Bulletin No. 10 Available

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U.S.A.

across the output terminals and the voltage to be measured is impressed across the infinite impedance input terminals. Negligible loading of the circuit under measurement will take place when any ordinary type of instrument is connected across the output of the amplifier.

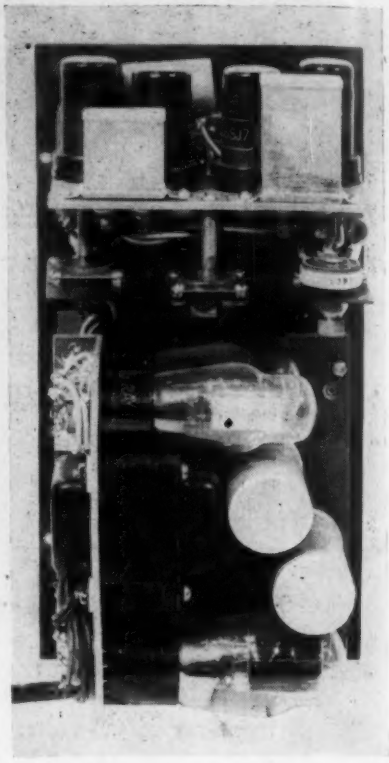

FIG. 2—Rear view of unit shows amplifier stages above, and power supply below

The normal gain of the amplifier system without feedback is approximately 70 db. However, to obtain gain stability, feedback through C_1, R_1 and R_2 is obtained from the output terminals of V_3 to the cathode of V_1. With switch S_1 in the 40-db position, the overall gain is adjusted to 40 db by means of R_3, a rheostat placed at the rear of the chassis. The divider in the grid circuit of V_2 prevents overloading of this stage at higher input levels.

With switch S_1 thrown in the 20-db position, R_1 in the feedback path is shorted out, the feedback is greatly increased and the overall gain is adjusted to 20 db by means of R_2. There is interaction between the 20-db and 40-db adjustments so that these must be made two or three times in succession until the proper settings are obtained.

It will be noted that the feedback factor is large for both the 20 and

Here's Why Your Antenna Installations Will Give

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1. **Their unusually low attenuation losses assure the most efficient transfer of energy between antenna and receiver or transmitter.**
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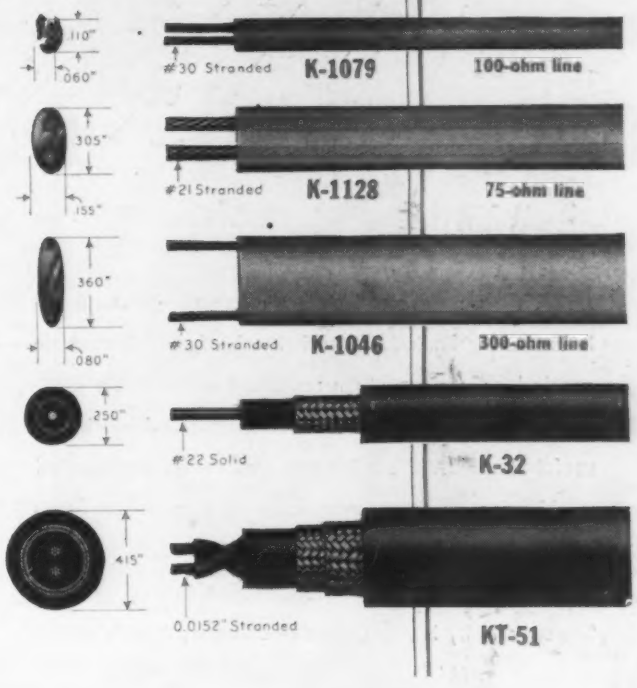

IN THE FIVE ITEMS listed here, there's a high-frequency cable for practically every antenna application. The K-1128 75-ohm line, for transmitter use—the K-1079 and K-1046 lines for general FM and Television service. The smooth oval cross-section of these 75, 100, and 300-ohm lines prevents the accumulation of foreign matter, thereby maintaining stable capacity characteristics. The K-32 and KT-51 coaxial cables offer peak performance for applications where locally-induced interference is severe.

For complete information and prices on these cables, see your local distributor. For other high-frequency cables —write to Federal, Dept. D113.

DATA FOR FEDERAL H-F CABLES

Type Number	Characteristic Impedance Ohms	Velocity of Propagation (in percent)	Capacitance Per Ft. mmf	Attenuation, Db per 100 Ft. Frequency in Megacycles				
				1.0	1.7	30	100	300
K-1079	100	71	15.5	.6	.75	2.8	5 2	8.8
K-1128	75	71	19.5	.3	.4	2.0	4.0	7.3
K-1046	300	81	4.0	.38	.57	.85	2.0	—
K-32	73	66	22	—	—	2.0	3.8	7.0
KT-51	95	66	16	—	—	1.8	3.8	7.5

•Reg. U. S. Pat. Off.

KEEPING FEDERAL YEARS AHEAD... is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

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MICA is a natural product, but in its native state its use is extremely limited. After it is mined, MICA must be graded, refined and then combined with suitable binders and laminated into sheets or compressed into divers useful shapes. All of this requires costly, complicated machinery and mature manufacturing experience. That's why, starting with a good natural product, MACALLEN always ends up with a superior manufactured product. This superiority is yours at no premium by merely standardizing on MACALLEN MICA and MICA PARTS.

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40-db gain settings. Consequently, the gain values are independent of variations in tubes, components, and supply voltage to a very good approximation.

So that it will present a high-impedance to an external circuit, the impedance transformer, V_4, is connected as an open-grid-circuit cathode follower. Consequently, a d-c isolation network must be connected to the input terminals of this stage when high d-c voltages to ground appear across the portion of the circuit under measurement. The gain of V_4 is very nearly unity due to the large cathode resistor incorporated in this stage.

The power supply is straightforward. The R-C filters are utilized in view of the space requirements. The V-R tubes are used to obtain a relatively constant B+ output of 255 volts. A potentiometer R_4 connected across the heater supply winding is used as an adjustable center tap to minimize hum output.

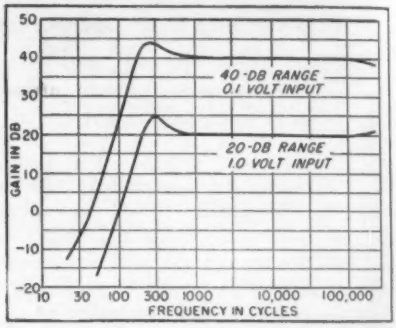

FIG. 3—Amplifier gain-versus-frequency characteristics for the 20-db and 40-db gain settings

The lower frequency pass characteristic of the amplifier was restricted to 1 kc to minimize hum resulting from the use of the 60-cycle filament-supply voltage and consequent 120-cycle variation of the plate current.

Construction and Alignment

The instrument is mounted in a case having the same physical dimensions as a Ballantine Model 300 voltmeter.

A rear-view photograph of the device with the cover removed appears in Fig. 2. Tubes V_1, V_2, V_3 and V_4, together with associated resistors and capacitors, are mounted

HERE ARE SIMPSON'S "BASIC 3" PROFIT-MAKERS FOR SERVICEMEN...

The serviceman who tries to "get along" with cheaply-made, run-of-the-mill test instruments is taking an outside chance on success. The business of radio servicing must be *built* from the bottom up on an endless succession of perfect jobs. Knowing what the trouble is, in a receiver, and knowing when that trouble is eliminated *can be no better than the test instruments that reveal them.*

The "Basic 3" Simpson instruments shown here are an extremely profitable investment for any serviceman. He needs all three and, in their price range, he cannot buy better anywhere else. In fact, in their price range they are unequalled. They will do more than many instruments selling for substantially more. These are facts easily demonstrable to any serviceman who will take the time to check up. And it is worth the time in the *cold cash of profits* to discover how Simpson engineering skill and uncompromising quality construction produce the *staying* accuracy for which Simpson instruments are famous.

MODEL 315 SIGNAL GENERATOR. Designed down to the most minute detail for highest accuracy, greatest stability, minimum leakage, and good wave form **$67.35**

MODEL 305 RC TUBE TESTER. Tests all tubes. Provides for filament voltages from .5 volts to and including 120 volts. Spare sockets for future tube developments **$59.50**

MODEL 260 HIGH SENSITIVITY SET TESTER. 20,000 ohms per volt, D.C. Voltage ranges to 5,000 volts A.C. and D.C. Resistance ranges to 20 megohms. Current ranges to 500 milliamperes, also 10 amperes D.C. **$38.95**

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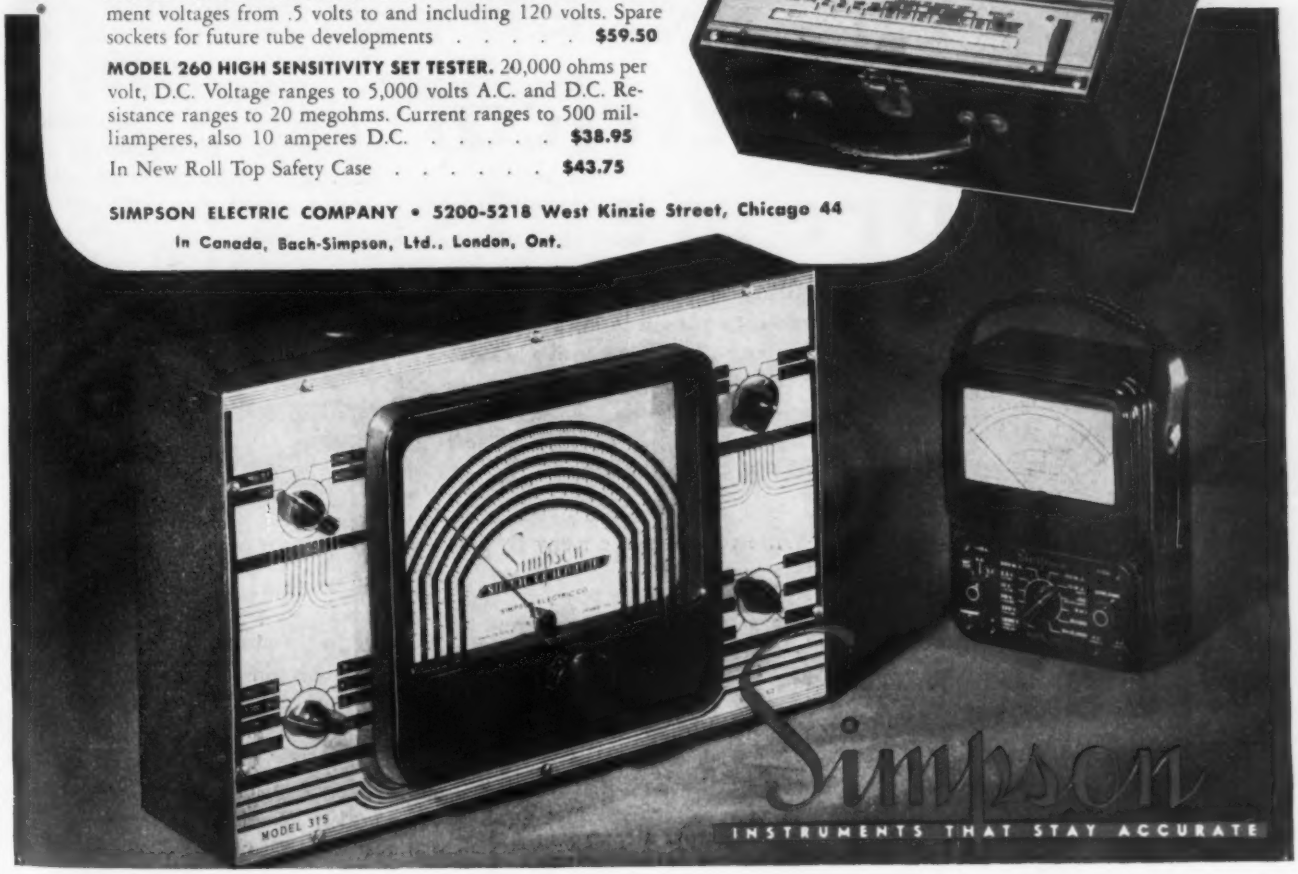

LOW-RESISTANCE TEST SET # 670C
1,000 to 500,000 micro-ohms
(Other ranges from 200 micro-ohms to 100 ohms)

KILOVOLTMETER # 785P
AC-DC 5-10-20 KV
(Other ranges from 1.5 to 200 KV)

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KELVIN-WHEATSTONE BRIDGE # 638-2
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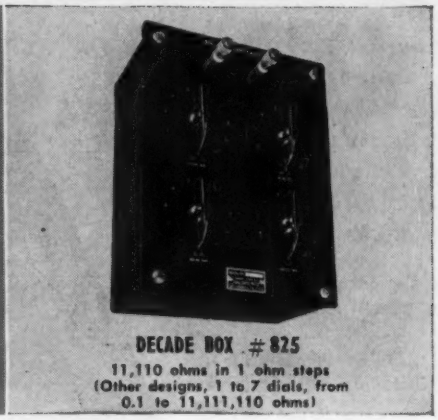

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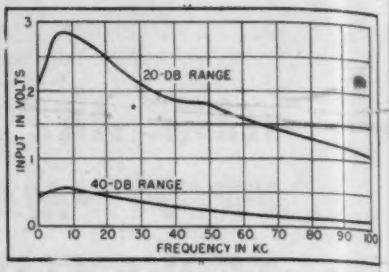

FIG. 4—Maximum input signals that the amplifier can handle without distortion are shown here as functions of frequency

on the small metal plate at the top. This entire assembly is mounted on Lord shock mounts to avoid microphonic difficulties. Flexible leads to this unit are provided for the same reason. The shock mounts are mounted on a metal plate bolted to the front panel and used as a shield between the amplifier section and the power supply.

The power supply, at the lower portion of Fig. 2, is a self-contained unit which is also bolted to the front panel.

In aligning the amplifier, a known input voltage source is connected to the input terminals and a voltmeter connected to the output terminals. The 20-db and 40-db gain adjustments are made and repeated until the two positions check satisfactorily after which the rheostat arms are locked in position.

Hum-adjustment potentiometer R_4 is adjusted by connecting an oscilloscope across the output terminals and, with the input terminals shorted and switch S_1 in the 40-db position, adjusting R_4 for minimum output signal.

Performance

The pass characteristics of the amplifier for the 20-db and 40-db gain positions are shown in Fig. 3. It will be observed that the response meets the specification of being flat within 0.5 db over the frequency range of 1 kc to 100 kc. It will also be noted that 60- and 120-cycle signals are greatly attenuated relative to the signals in the pass range of the amplifier.

Figure 4 shows the maximum voltage that may be impressed across the input terminals as a function of frequency under the condition that negligible distortion occur. Distortion was checked by

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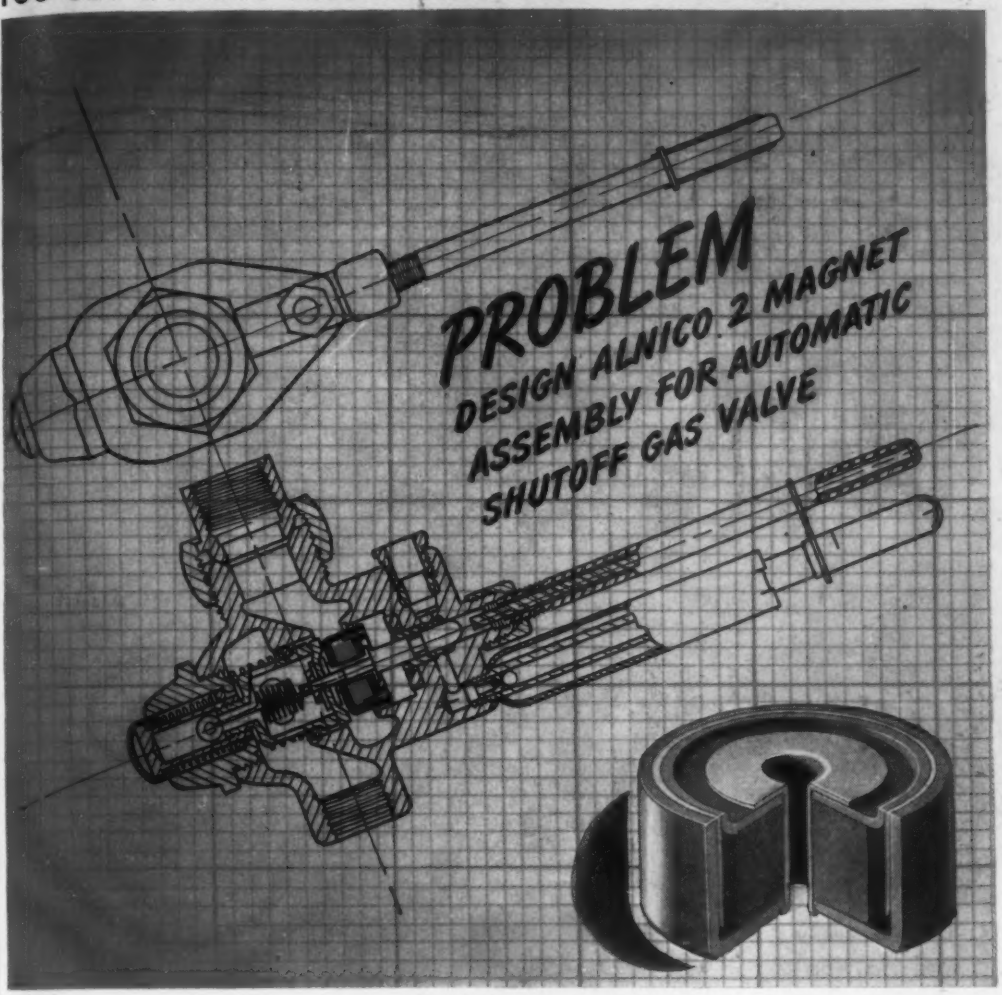

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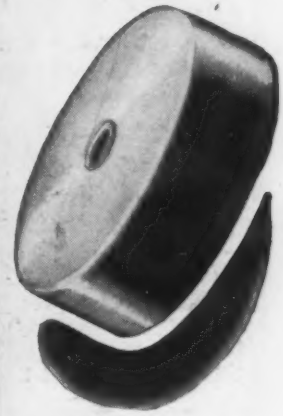

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placing an oscilloscope across the output terminals while the data for these curves were being obtained.

The equivalent input noise level of the amplifier was found to be 90 db below 1 volt on the 40-db range and 96 db below 1 volt on the 20-db range. These results, in conjunction with those given in Fig. 4, determine the operating range of the instrument in terms of input signal level.

Tube Production Techniques

By Vincent G. Jarman
Electronics Shops
Western Electric Co.
New York, N. Y.

Two innovations in tube assembly have improved the quality and reduced the cost of manufacturing vacuum tubes. One is a new type electrode holder on bench welders, and the other is an adjustment fixture for examining alignment of grid laterals.

Holder for Welder Electrodes

Resistance welding is used in assembling intricate metal parts of vacuum tubes. The former practice

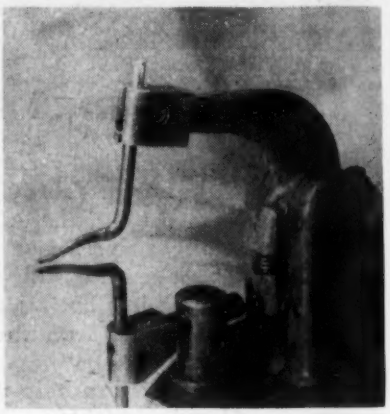

Fig. 1—Oldstyle welding electrodes

involved insertion of electrodes directly in the head of the welder as illustrated in Fig. 1. The entire electrode was made of costly rod and was turned down and tipped in the company shop. As the tip wore, a maintenance man refaced it until it had to be replaced, although a great part of the original material remained.

To simplify maintenance and reduce waste the electrode holder shown in Fig. 2 was developed. It fits into the welder head exactly as

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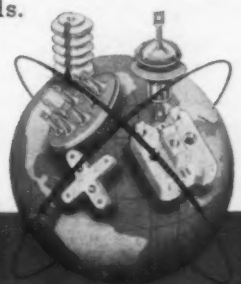

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Fig. 2—New electrodes in holders

did the former electrode. As the new electrodes are held in swivels, they can be moved toward each other as they wear; faces can be prepared and maintained by the operators. The new electrodes are either ⅛ or 3/16 inch as compared to the ¼ inch size used formerly. Average life of the old electrodes was about three weeks, and about 80 percent of the material was discarded.

The new electrodes last over three months and have been used in assemblying the 2K56 metal klystron and such miniature tubes as the 403B, 2C51, 399A, and 400A. Whereas the old type electrode tip became larger as the electrode wore, the tip of the new type electrode remains the same. Also, an extension of the use of electrode holders permits holding several electrodes to make multiple welds.

Grid Alignment Fixture

In assembling tubes that employ two or more grids with aligned lateral wires, operators held the tubes for inspection and adjustment in different positions with the result that the alignment was along the same axis. The variations in manufacture could well have caused important variations in tube performance. With the new adjustment fixture shown in Fig. 3, the grids can be inspected from only one position.

The fixture consists of a viewing mask with a slit in it. The grid support is placed in a block that can be moved vertically and turned over 180 degrees. The view-

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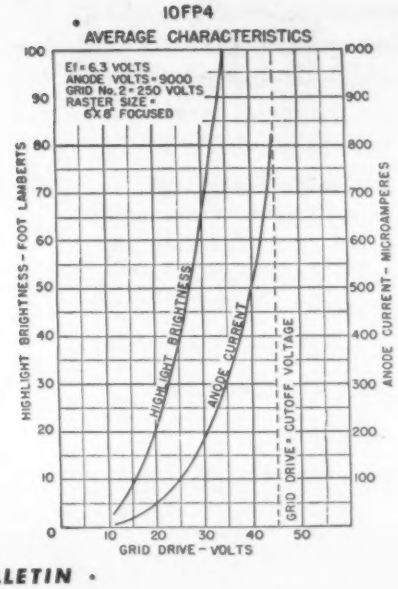
Base	Small Shell Duodecal 7 Pin
Anode Terminal	Cavity
Anode Volts (Max.)	13,000
Anode Volts (Operating)	9,000
External Coating (Optional): 500 mmf.	



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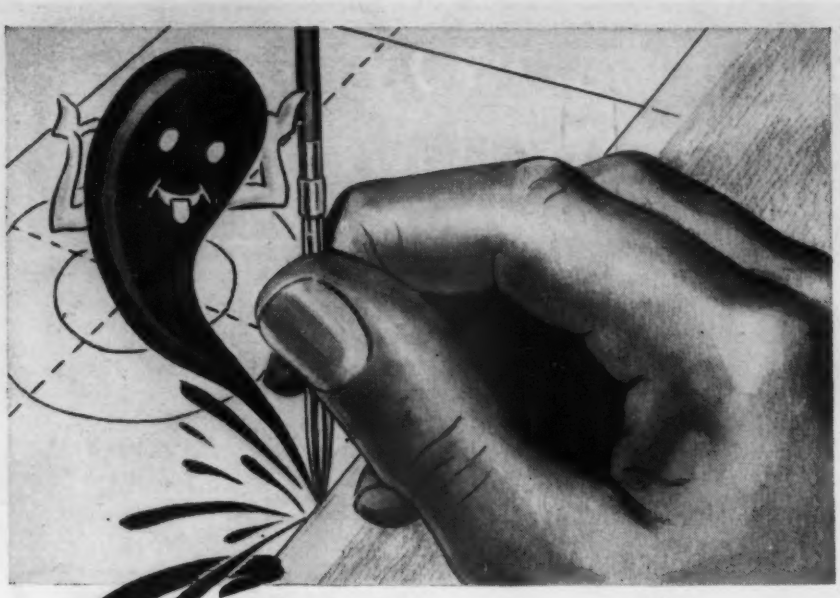

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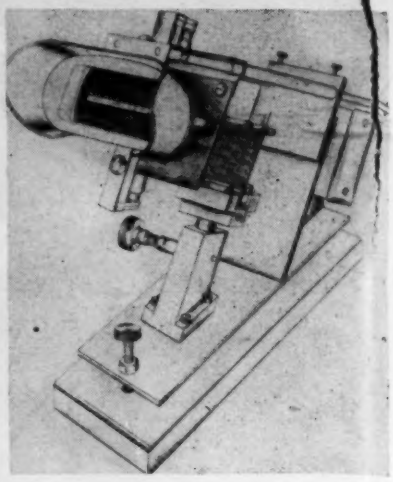

Fig. 3—Grid adjustment fixture for viewing lateral grid wires

ing mask with its magnifying lens can be moved relative to the block for accommodation to various operators eyes. A fluorescent lamp behind one vertical edge of the screen illuminates the grid assembly.

The operator mounts the grid assembly on the block and moves it upwards, viewing the individual windings through the slit. At the last winding, the block is reversed and the operation repeated for the other side of the grid as the block is lowered. A small probe can be inserted to adjust laterals that are out of line. The fixture has increased both the thoroughness of inspection and the consistency of tubes produced in this shop.

Diode Contact Potential For Negative Bias

By Howard T. Sterling
New York, N. Y.

Ever since the discovery of the so-called Edison effect, contact potential has been a source of interest and frequently of annoyance to workers in electronics. It can, however, serve as a convenient source of bias in high gain audio amplifiers and in the r-f and i-f stages of receivers.

When a diode is connected as shown in Fig. 1 there will be a d-c output voltage of from zero to something over 1 volt depending upon the value of the load resistor. The curve in Fig. 1 shows this char-

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Speed Nut ("J" Type)	18	.1116			.1116
Bolt (5/16 - 10 x 5/8)	18	.0828			.0828
Plain Washer	18	.0234			.0234
Attach 9 Speed Nuts to R & L Wheelhouse Panels			1100	.1925	.3025
Assemble R & L Fenders to Body			.1350	.2363	.3713
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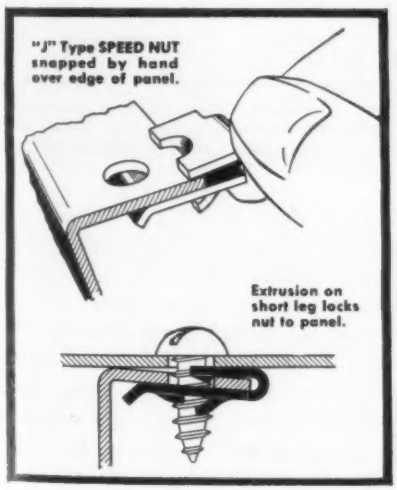

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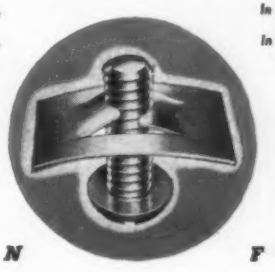

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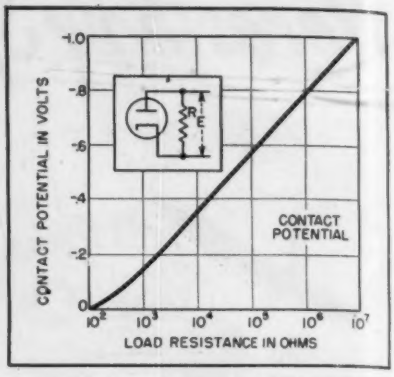


Fig. 1—Diode contact potential increases as value of load resistor is increased

acteristic for a typical 6H6 diode. This curve should be taken merely as indicative; the exact voltage developed will depend on several factors, such as heater voltage and the condition of the cathode. Other rectifiers will conform approximately to this characteristic.

In a triode, the grid will demonstrate the same sort of phenomenon, since it acts as a diode plate. It has become common practice to operate high-mu triodes as shown in Fig. 2A, using a high value of grid resistance, and hence permitting the tube to bias itself. A refinement of this system is to use one of the diodes of a tube like a 6SQ7 to provide bias, as shown in Fig. 2B. In this case the audio bypass capacitor *C* is necessary only when the peak signal approaches the bias voltage.

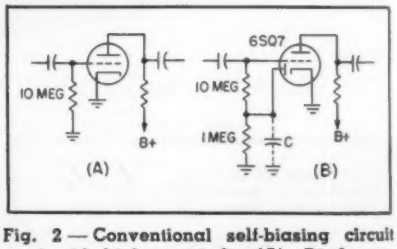
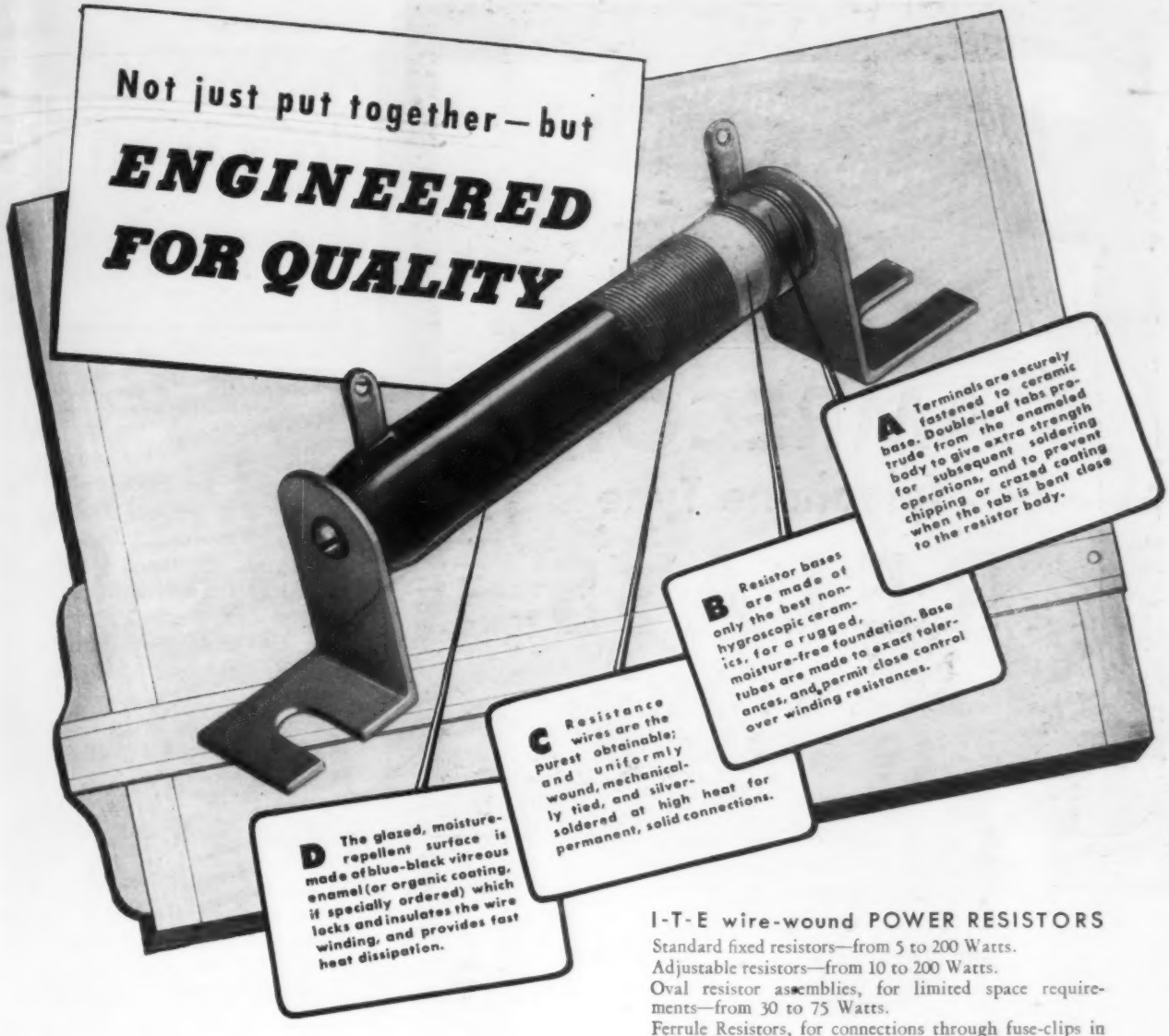


Fig. 2 — Conventional self-biasing circuit used with high-mu triodes (A). Diode section of duo-diode triode is used to furnish bias (B)

In a receiver with a number of r-f and i-f stages, considerable saving in cathode resistors and bypass capacitors may be achieved by the use of an initial diode bias on the avc line, as shown in Fig. 3. Two diode sections are shown connected in series across the avc line with an avc decoupling resistor of two megohms. With a load of one megohm per diode, it can be seen from Fig. 1 that there will be an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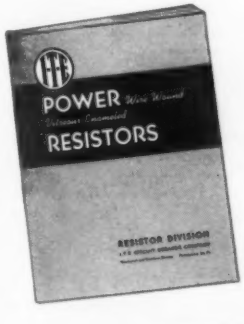

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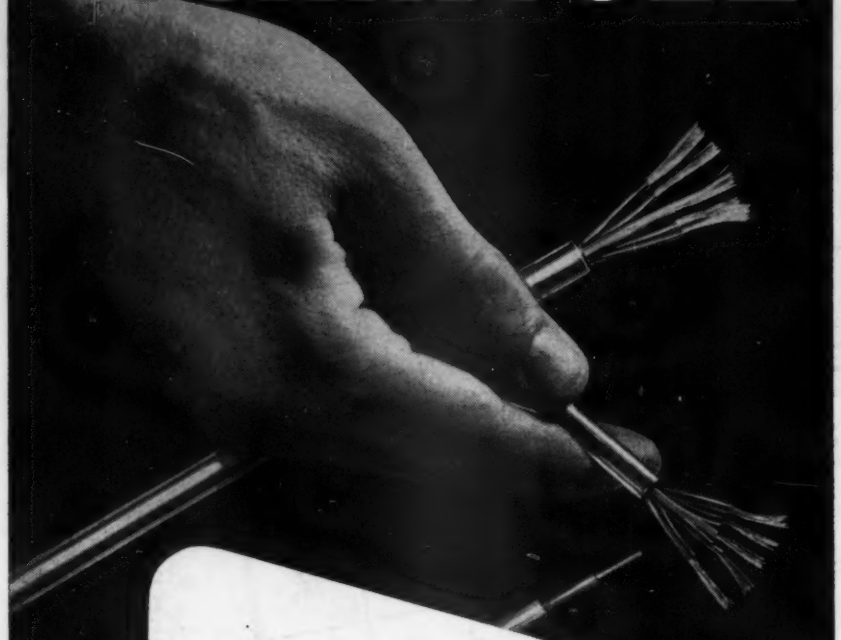

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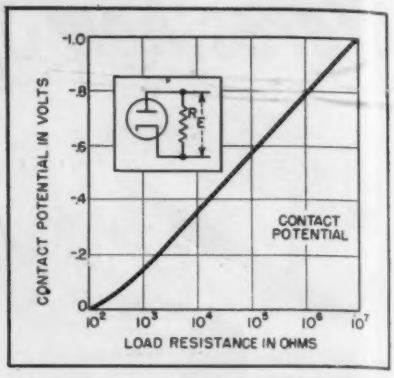

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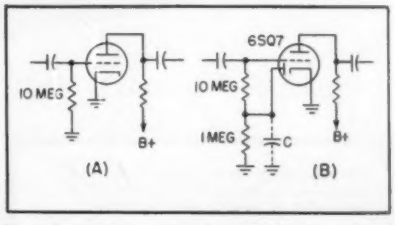
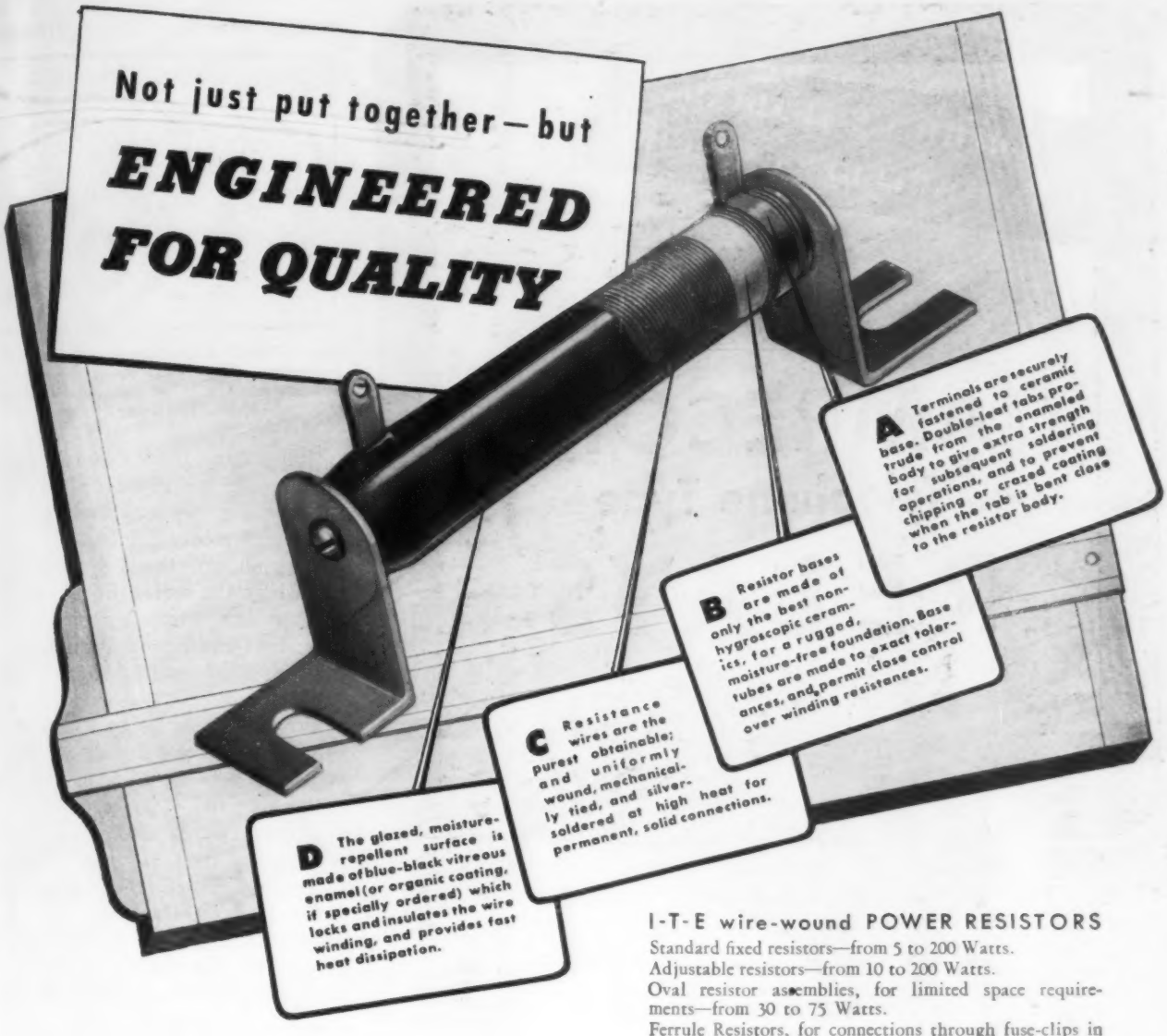


Fig. 2 — Conventional self-biasing circuit used with high-mu triodes (A). Diode section of duo-diode triode is used to furnish bias (B)

In a receiver with a number of r-f and i-f stages, considerable saving in cathode resistors and bypass capacitors may be achieved by the use of an initial diode bias on the avc line, as shown in Fig. 3. Two diode sections are shown connected in series across the avc line with an avc decoupling resistor of two megohms. With a load of one megohm per diode, it can be seen from Fig. 1 that there will be an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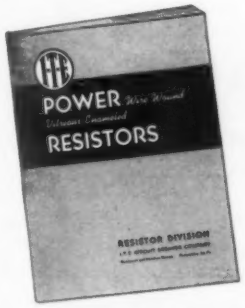

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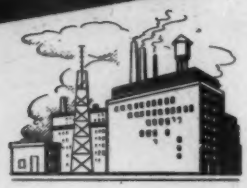

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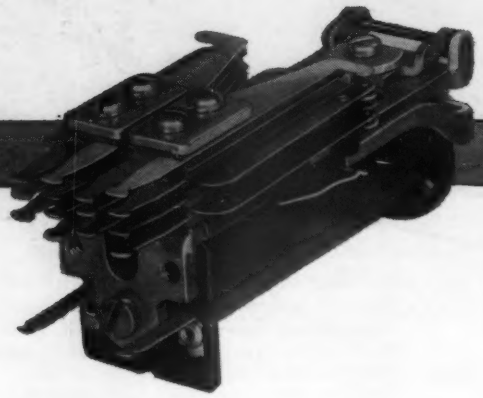

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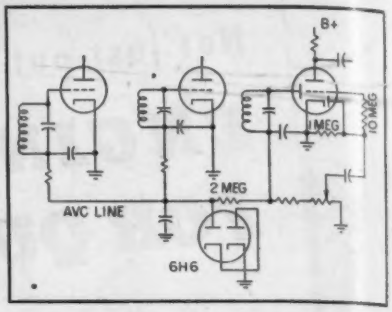

Fig. 3—Initial diode bias on avc line saves capacitors and resistors in r-f and i-f cathode circuits, also provides threshold voltage for delayed avc

initial bias on the r-f and i-f tubes of 0.8 volt per diode or 1.6 volts total, which is more than enough for most modern tubes. In the circuit shown, the 1.6 volts furnished by the series diodes acts as delayed avc threshold voltage. If more bias and/or more avc delay is desired, a second double diode may be connected in series with the first. It may be noted that one of the diodes of the duo-diode triode is used for triode bias in this circuit.

In a diode detector, the major source of distortion apparently lies in the fact that the d-c load and the audio load on the diode are not equal. In a typical circuit shown in Fig. 4A, the d-c load consists of R_1 and R_2 in series. For audio frequencies, however, there is the additional load of R_3 plus the effect of R_1 in parallel with whatever part of R_2 is in use. Common practice is to make R_4 as high as possible, usu-

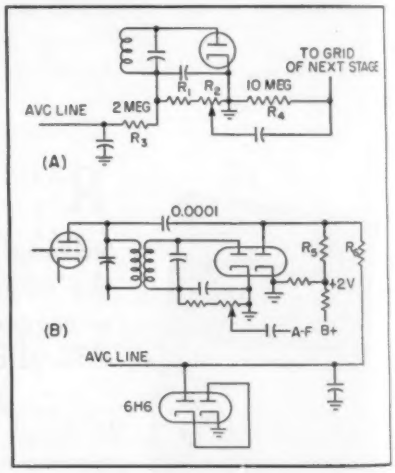

Fig. 4 — Conventional detector-avc circuit uses common diode (A). To minimize distortion, separate detector and avc diode are combined with contact-potential bias circuit (B)

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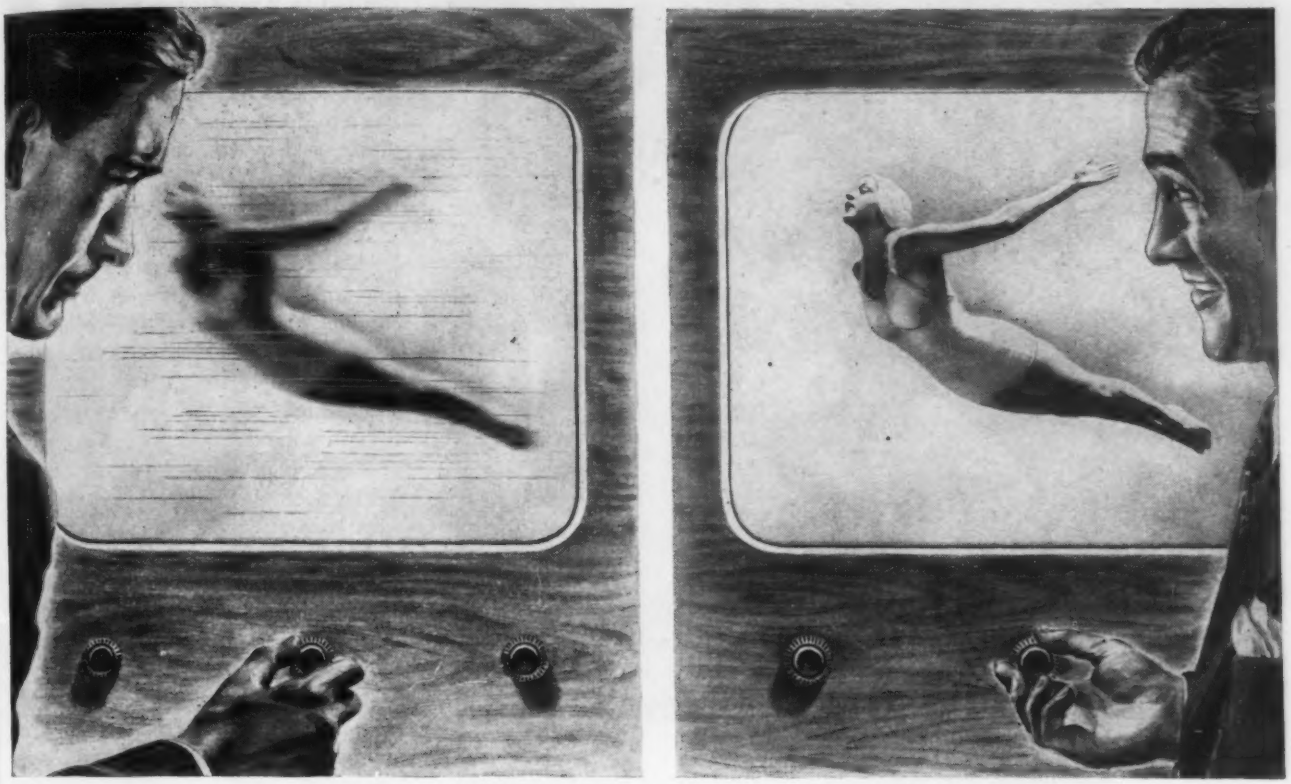

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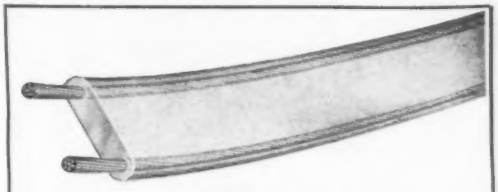

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ally about 10 megohms. This is in keeping with the use of contact potential bias in a high-mu triode. R_s is made as high as is permissable for use in the grid circuit of the r-f and i-f tubes. This value is usually limited to 2 megohms, representing a somewhat more serious load on the diode. Distortion from this source, that is, the audio load of the avc decoupling resistor, may be eliminated by the use of a separate diode as avc rectifier, as was common practice several years ago.

A simple form of delayed avc may be realized in this manner by biasing this diode so that it will not conduct until the avc threshold has been reached. The disadvantage of this method is that with signals of the same order of magnitude as this threshold, the avc voltage will be dependent upon the modulation. With normal modulation percentages this effect is not too serious.

A separate avc rectifier lends itself to use with contact potential bias as shown in Fig. 4B. In this case, since R_s is returned to the negative bias voltage, R_s will have to be returned to a point several volts positive with respect to the cathode so that the diode will not be cut off.

A number of combinations suggest themselves in assembling a

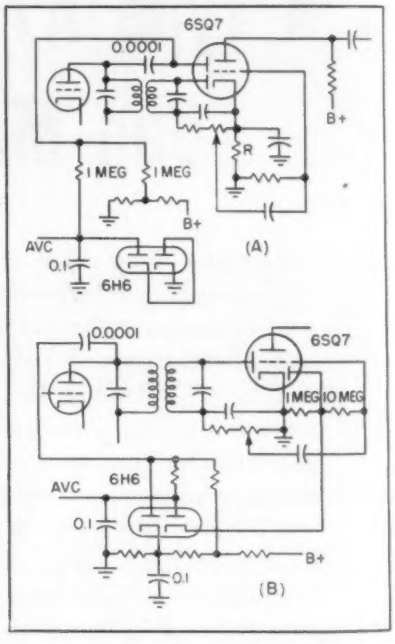

Fig. 5—Additional avc delay may be had by increasing value of R (A). Maximum simplicity and economy of parts are achieved by use of one diode section for both audio grid bias and r-f and i-f bias (B)

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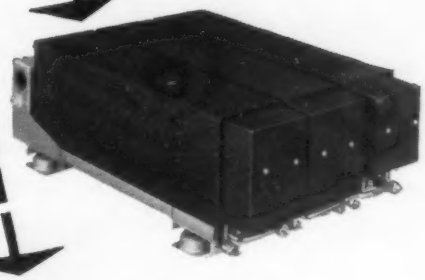

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practical circuit. The double-diode triode can be used together with another double diode as in Fig. 5A. Here, the triode is conventionally biased and any additional avc delay desired may be achieved by increasing the value of the resistor *R*. A circuit similar to that in Fig. 3 may be used with an additional double diode, of which one section can be the avc rectifier and the other section can be put in series with the bias diodes to provide additional bias and delay voltage. A system using one diode for both audio grid bias, and as part of the r-f and i-f bias, is shown in Fig. 5B. This circuit makes use of all the considerations put forth in this paper, and represents what is probably the maximum in simplicity and economoy of parts.

In using any of these diode biasing systems, it should be remembered that the contact potential will vary widely with change in heater voltage, and should be used for bias in circuits where stability is important only when the circuit is balanced. Examples may be found in some vacuum-tube voltmeters where the contact potential of the diode used as rectifier is balanced by that of a second diode.

Another source of bias has been suggested which, while it does not use diodes, is rather interesting. A number of photronic cells, connected in series and illuminated by a single pilot lamp, provide a significant bias voltage with a fairly low internal impedance.

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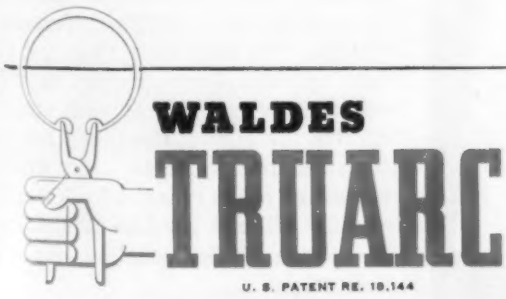

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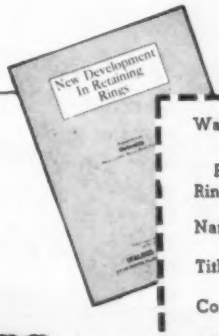

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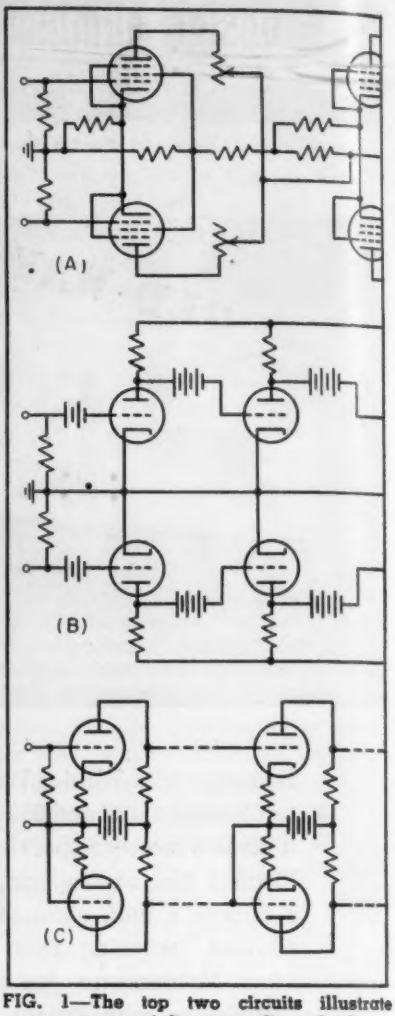


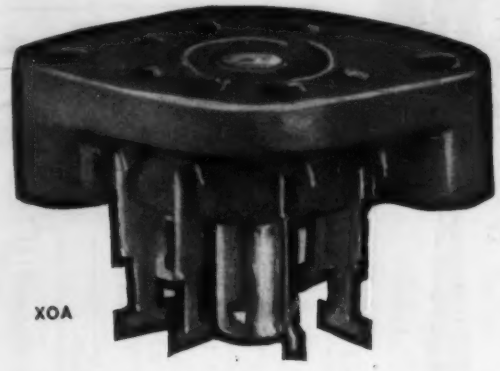
FIG. 1—The top two circuits illustrate common types of direct coupling; the lower one shows an improved method

beyond satisfactory operating limits. Were common cathode resistors used, the effect would be decreased, but would not be eliminated.

Difficulty of adjustment and the passing on of drift voltages can be eliminated by the circuit of Fig. 1C. The amplifier consists of a series of independent stages linked with only two connections (shown dotted). One connection carries the signal; the other, the reference voltage. To keep each stage separate, individual power supplies are used. Only one side of each stage carries the signal, the other being to cancel drift voltages. Any drift affecting both tubes of a stage equally will not produce a change in voltage at the coupling out of that stage.

Circuit Behavior

Because only one channel of the balanced amplifier carries signal,



XOA

● The XOA Socket for Miniature Button 7-pin bases is made of low-loss mica-filled bakelite. It mounts with two 4-40 screws. Terminals for the Type XOA extend axially from the socket. Type XOR is identical to Type XOA, but has terminals extending radially. Short heavy terminals reduce contact inductance. Lower effective capacity between terminals reduces circuit capacity.

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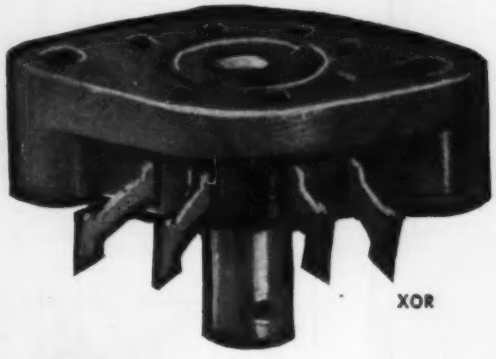
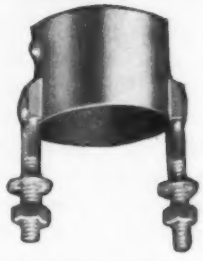


XOR

● The XOS tube shield is a two-piece shield for Miniature Button 7-pin base tubes. It mounts with the XOA or XOR socket and is available in three sizes, XOS-1 (1-3/16" high), XOS-2 (1½" high), and XOS-3 (2" high).



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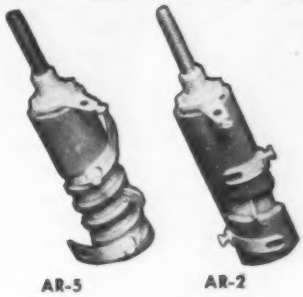

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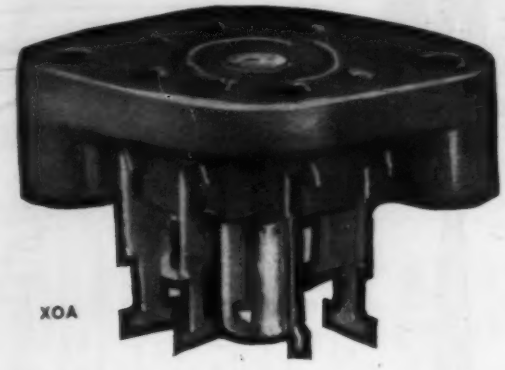

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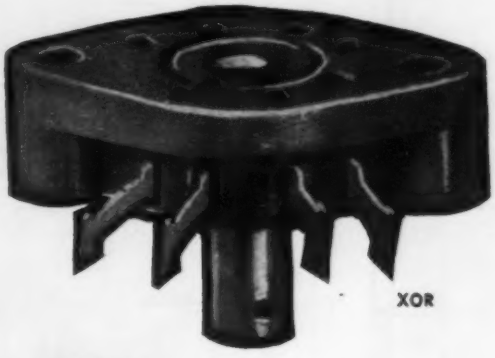
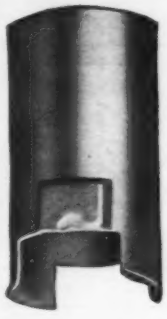


XOR



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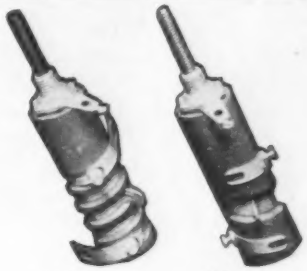
XR-50

● XR-50 coil forms may be wound as desired to provide a permeability tuned coil. The form winding length is 11/16" and the form winding diameter is ½". The iron slug is ⅜" diameter by ½" long.



AR-5 AR-2

● The AR-2 and AR-5 coils are high Q permeability tuned RF coils. The AR-2 coil tunes from 75 mc to 220 mc and the AR-5 coil tunes from 37 mc to 110 mc with suitable capacitors.

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RECTIFIERS
GRID CONTROL RECTIFIERS

ELECTRON ART
(continued from p 138)

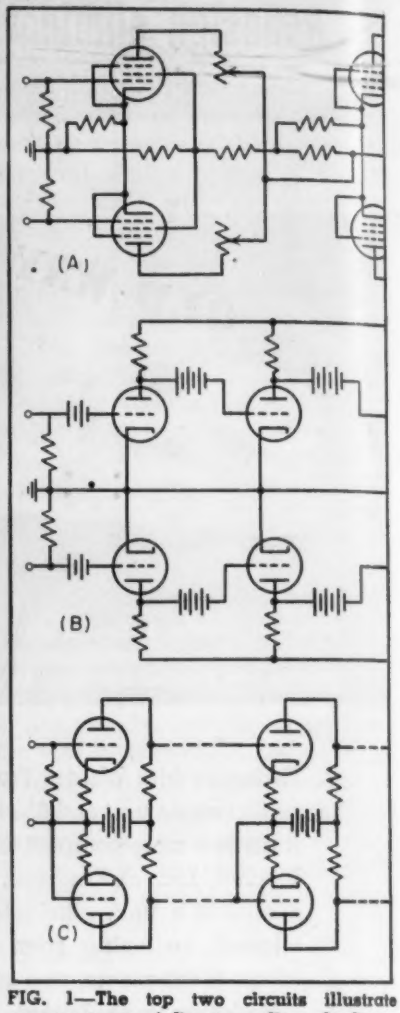

FIG. 1—The top two circuits illustrate common types of direct coupling; the lower one shows an improved method

beyond satisfactory operating limits. Were common cathode resistors used, the effect would be decreased, but would not be eliminated.

Difficulty of adjustment and the passing on of drift voltages can be eliminated by the circuit of Fig. 1C. The amplifier consists of a series of independent stages linked with only two connections (shown dotted). One connection carries the signal; the other, the reference voltage. To keep each stage separate, individual power supplies are used. Only one side of each stage carries the signal, the other being to cancel drift voltages. Any drift affecting both tubes of a stage equally will not produce a change in voltage at the coupling out of that stage.

Circuit Behavior

Because only one channel of the balanced amplifier carries signal,

BIG CAPACITY

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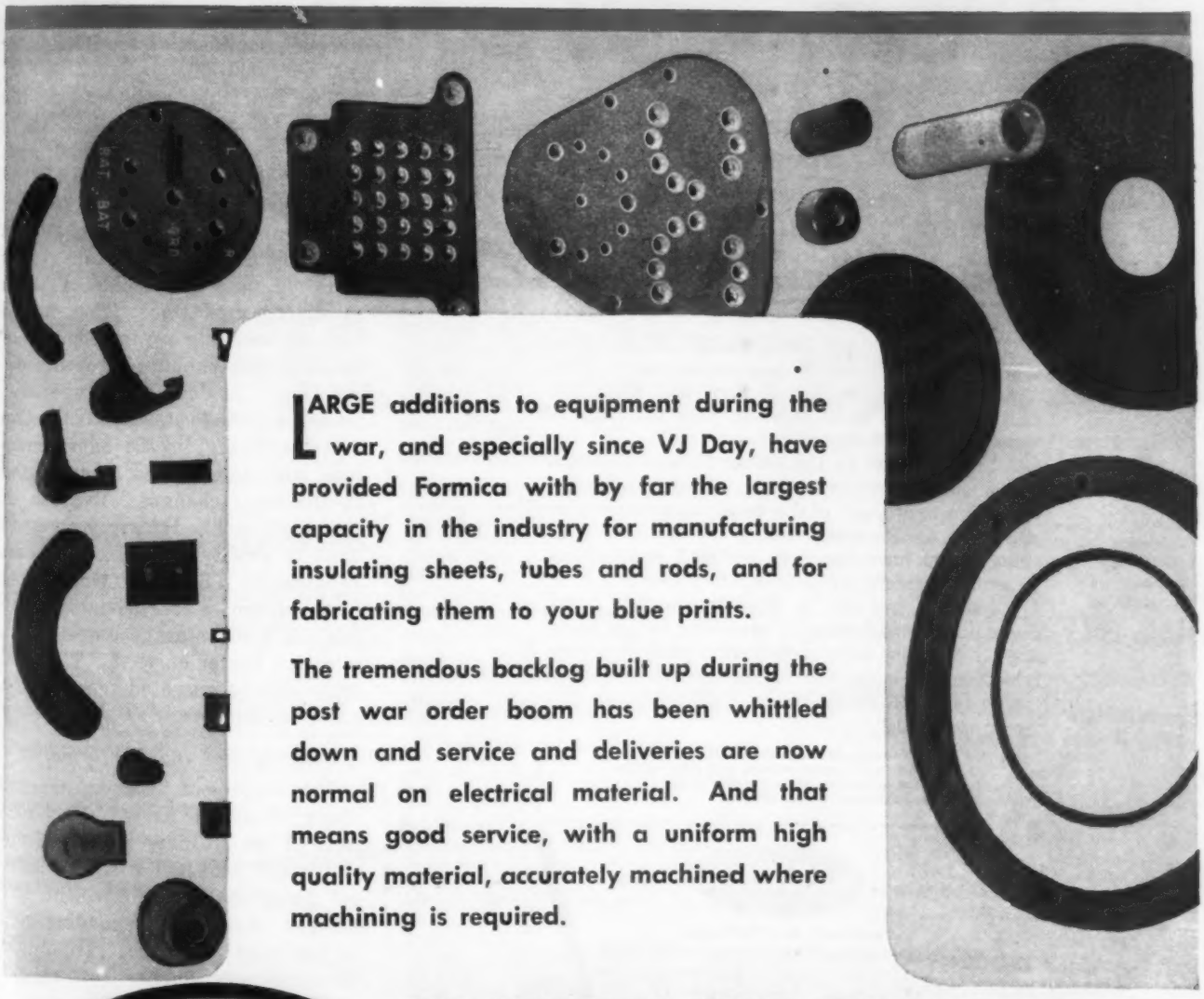

LARGE additions to equipment during the war, and especially since VJ Day, have provided Formica with by far the largest capacity in the industry for manufacturing insulating sheets, tubes and rods, and for fabricating them to your blue prints.

The tremendous backlog built up during the post war order boom has been whittled down and service and deliveries are now normal on electrical material. And that means good service, with a uniform high quality material, accurately machined where machining is required.

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At FM frequencies, transmission lines are tricky.

That's why broadcasters who value reliability buy ANDREW transmission lines. Having bought the best, they find it good business to have Andrew engineers install it.

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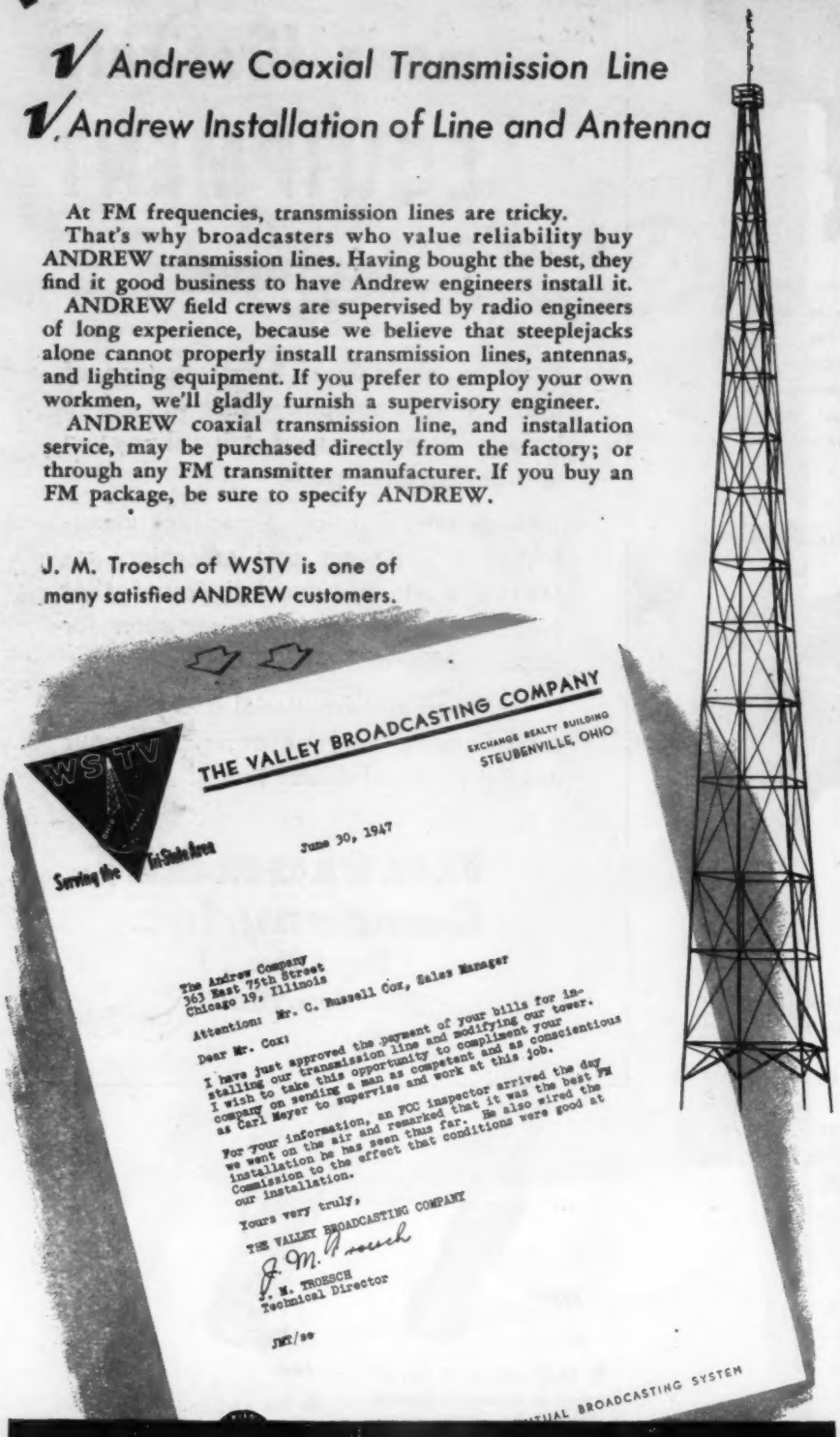
ANDREW coaxial transmission line, and installation service, may be purchased directly from the factory; or through any FM transmitter manufacturer. If you buy an FM package, be sure to specify ANDREW.

J. M. Troesch of WSTV is one of many satisfied ANDREW customers.



WSTV — Serving the Tri-State Area

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EXCHANGE REALTY BUILDING
STEUBENVILLE, OHIO

June 30, 1947

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Chicago 19, Illinois

Attention: Mr. C. Russell Cox, Sales Manager

Dear Mr. Cox:

I have just approved the payment of your bills for installing our transmission line and modifying our tower. I wish to take this opportunity to compliment your company on sending a man as competent and as conscientious as Carl Meyer to supervise and work at this job.

For your information, an FCC inspector arrived the day we went on the air and remarked that it was the best FM installation he has seen thus far. He also wired the Commission to the effect that conditions were good at our installation.

Yours very truly,

THE VALLEY BROADCASTING COMPANY

J. M. Troesch

J. M. TROESCH
Technical Director

JMT/ss

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ELECTRON ART (continued)

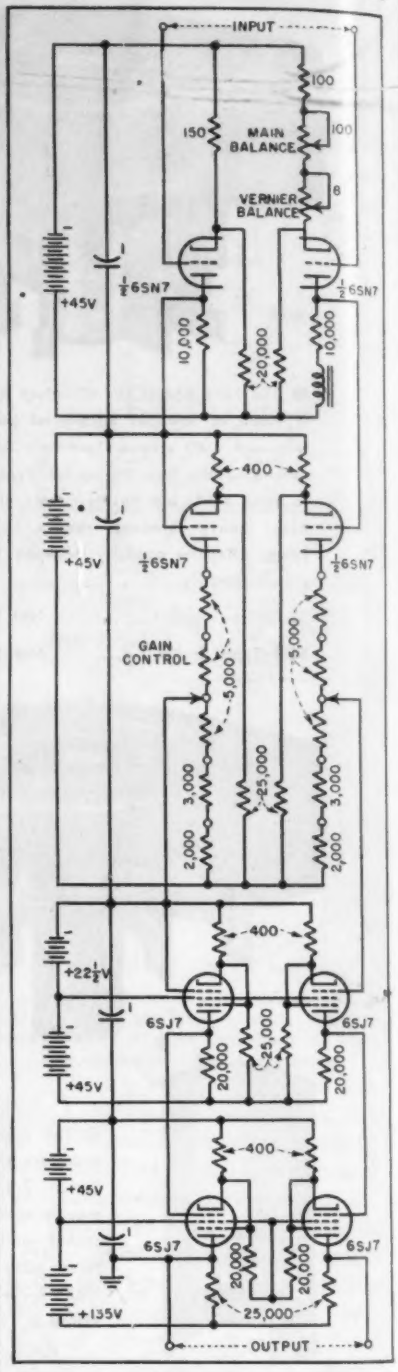

FIG. 2—Four stage directly coupled amplifier is stabilized against drifts

no special shielding or placement of parts is necessary in the nonsignal channel. Furthermore there can be no interaction between a nonsignal half of a stage and any other stage, or, because no common cathode resistor is used, between nonsignal and signal halves of a single stage. As a result the nonsignal halves of the stages can be adjusted without affecting the rest of the amplifier, and once it is adjusted, that half of the amplifier

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Raytheon employs a large engineering staff, maintains a model shop for producing sample units, and is building custom-engineered magnetic components to meet the specific service requirements of large and small manufacturers of electrical and electronic apparatus.

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can be forgotten. (It is assumed that there is no grid current in the signal channel. If there is grid current, low plate loads can minimize its effect.)

Because it is impractical for components of both channels to exactly correspond, some adjustment is necessary. Fortunately adjustment of grid bias in the first stage will satisfactorily correct all succeeding stages. If corresponding components of both channels are closed matched, changes in grid bias from such a single adjustment will not move the tubes out of operating limit.

Figure 2 shows a four stage version of this type amplifier; filament wiring and battery disconnects are omitted. The voltage gain is about 10,000. A final amplifier stage (not shown) has been used to bring the over-all amplification to either 250,000 or 1,000,000.

Two variable resistors in the cathode circuit if the first stage provide balancing adjustment. Cathode degeneration is reduced by using bleeder resistors. A stepped gain control is introduced between the second and third stages that does not destroy amplifier balance or drift cancelation. The capacitors, by lowering a-c impedance between power supplies, prevents oscillation. A dual type tube was chosen for the first stage as the two sections, being in the same envelope, are more apt to be subjected to the same changes. Because of the high gain, battery power is used to avoid hum. Medium size B-batteries (Burgess No. 5308) have shown a surprisingly long life. A 6-volt storage battery supplies the heater current. The final stage can be operated from an a-c powered supply.

Construction and Performance

Two amplifiers were constructed using standard parts. Resistors were of the ordinary metallized variety, each one in the signal-channel being matched to within two percent of the corresponding one in the nonsignal side. To obtain the necessary fineness of adjustment, the 8-ohm vernier was a specially made spiral slide wire. Signal-carrying wiring was kept isolated from other parts where

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ROCKBESTOS ALL-ASBESTOS
impregnated asbestos and asbestos braid
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4. Impregnated asbestos insulation that withstands heat of overloads and aging and won't become brittle, crack, rot or burn.
5. Conductors are perfectly centered in helically applied non-flowing insulation and will always remain so.

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Sizes No. 8 to 20 AWG solid or stranded copper, monel or nickel conductors insulated with .031" or .040" of impregnated felted asbestos in black, white or colors.

Whether you make waffle irons, hot-plates, small motors, ranges, water heaters, radios, ovens or blueprint machines, we can give you an asbestos lead wire made to fit the electrical and mechanical requirements of your product.

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(National Electrical Code, Type AVA)

Size No. 18 AWG to 1,000,000 CM insulated with two walls of impregnated asbestos and a high-dielectric varnished cambric insert, with a heavy asbestos braid overall.

Use this apparatus cable for coil connections, motor and transformer leads exposed to overloads or high ambient temperatures. It makes a permanent installation as it is resistant to heat, flame, oil, grease and moisture.

ROCKBESTOS A.V.C. 600 VOLT SWITCHBOARD WIRE

(National Electrical Code, Type AVB)

Sizes No. 18 to No. 4/0 AWG with varnished cambric and impregnated asbestos insulation and gray, black, white or colored flameproof braid.

Combine fire insurance and fine appearance in your switchboards with Rockbestos Switchboard Wire. It is fireproof and will not dry out under heat. Sharp, clean bends can be made without cracking as the asbestos wall acts as a cushion under the braid. Rockbestos A.V.C. Hinge Cable and Switchboard Bus Cable have same fireproof and heatproof characteristics.

ROCKBESTOS ALL-ASBESTOS 600 VOLT FLEXIBLE CORD

Sizes No. 10 to 18 AWG with two or three conductors insulated with impregnated felted asbestos and covered with a heavy asbestos braid.

This heavy duty heat-resisting flexible cord is ideal for high wattage lighting units, apparatus, floodlights, etc., that are used in hot spots or develop heat in operation. For moisture resistant type specify Rockbestos A.V.C. construction.

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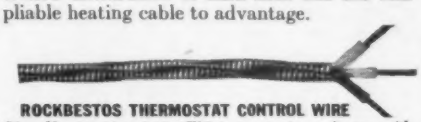
No. 19 AWG nickel-chromium resistance wire insulated with .040" of impregnated felted asbestos and covered with 4/64" waterproof lead sheath.

Manufacturers of photographic developing tanks, candy making equipment, soil heating cable kits and other devices requiring controlled distribution of mild heat can use this pliable heating cable to advantage.



ROCKBESTOS THERMOSTAT CONTROL WIRE

Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", or .025" or (for 115 volt service) .031" of impregnated felted asbestos insulation and steel armor.

A multi-conductor control wire for low voltage intercommunicating, signal, and temperature control systems. Lifetime heatproof, fireproof insulation and rugged steel armor give trouble-proof circuits.

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ROCKBESTOS A.V.C. 600 VOLT POWER CABLE

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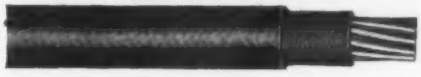
Sizes No. 18 AWG to 2,000,000 CM insulated with laminated felted asbestos, varnished cambric, and asbestos braid. Other constructions for service voltages to 5000.

For protection against failure caused by conductor-heating overloads and high ambient temperatures use this permanently insulated heat and flame resistant power cable for the internal wiring and power leads of products.

ROCKBESTOS FIREWALL HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt insulated with high dielectric synthetic tape, impregnated felted asbestos and covered with color coded lacquered glass braid.

Originally designed to meet the demand of airborne radio equipment manufacturers for a flame and heat resistant wire and widely used since in ground, marine and mobile communications systems, electronic devices and apparatus. Operating temperature range 125° C. to minus 50° C. Ideal for wiring harnesses in compact apparatus and small motor, coil, transformer and dynamotor leads. Also in twisted pair, tripled or cabled multi-conductor constructions.



ROCKBESTOS ALL-ASBESTOS 600 VOLT RHEOSTAT CABLE

(National Electrical Code, Type AIA)

Sizes No. 18 AWG to 1,000,000 CM insulated with a heavy wall of felted asbestos, covered with a rugged asbestos braid finished in black, white or colors.

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Sizes No. 10 to 18 AWG stranded plain copper conductors insulated with impregnated felted asbestos, polarized, twisted together and covered with a cotton braid.

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WON'T bake brittle, bloom, burn or rot— RESIST heat, moisture, oil, grease and fumes

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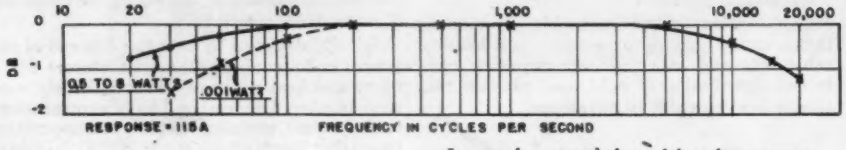
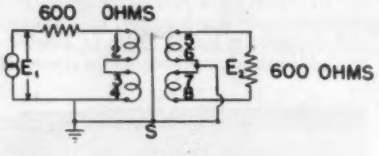
The Wire with Permanent Insulation

1st LINE PERFORMANCE *Proved in* ADC 2nd Line Transformer

An **ADC** 115A (Industrial Series) impedance matching transformer, picked at random from stock, was submitted to tests to compare its performance with that of other makes of *1st line* transformers. Here are the results. Compare performance of the **ADC** transformer with that of other makes.

FREQUENCY RESPONSE

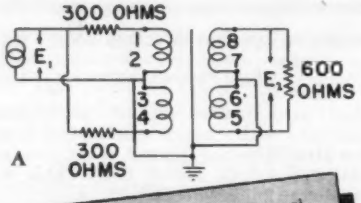




It may be noted that altho the permeability of magnetic materials drops at low flux densities, the **ADC** transformer has sufficient reserve inductance to allow for this even at low power levels. At 40 db below maximum power level it exceeds the response guarantee. Insertion loss at 1,000 cps was 0.75 db.

LONGITUDINAL BALANCE

The most common interference voltages encountered in telephone line transmission are longitudinal; that is, the induced voltages in both wires are in phase with respect to ground. These can be removed from the signal voltage only by means of a well balanced line transformer. Illustration "A" shows the test circuit used to measure the degree of removal of these interference voltages. Level reduction on the **ADC** 115A transformer was 67 db at 100 cps and 56 db at 10,000 cps.



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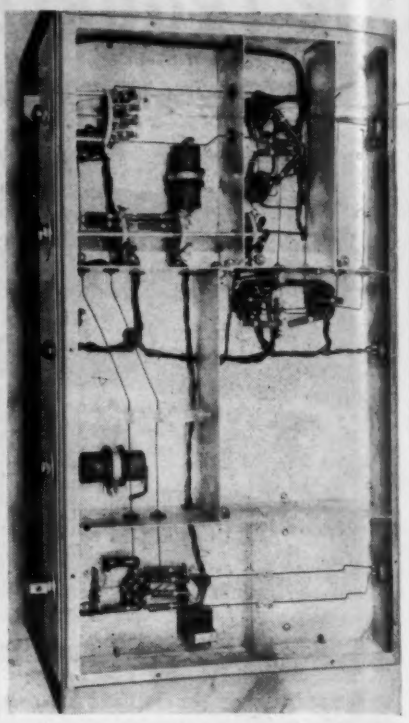
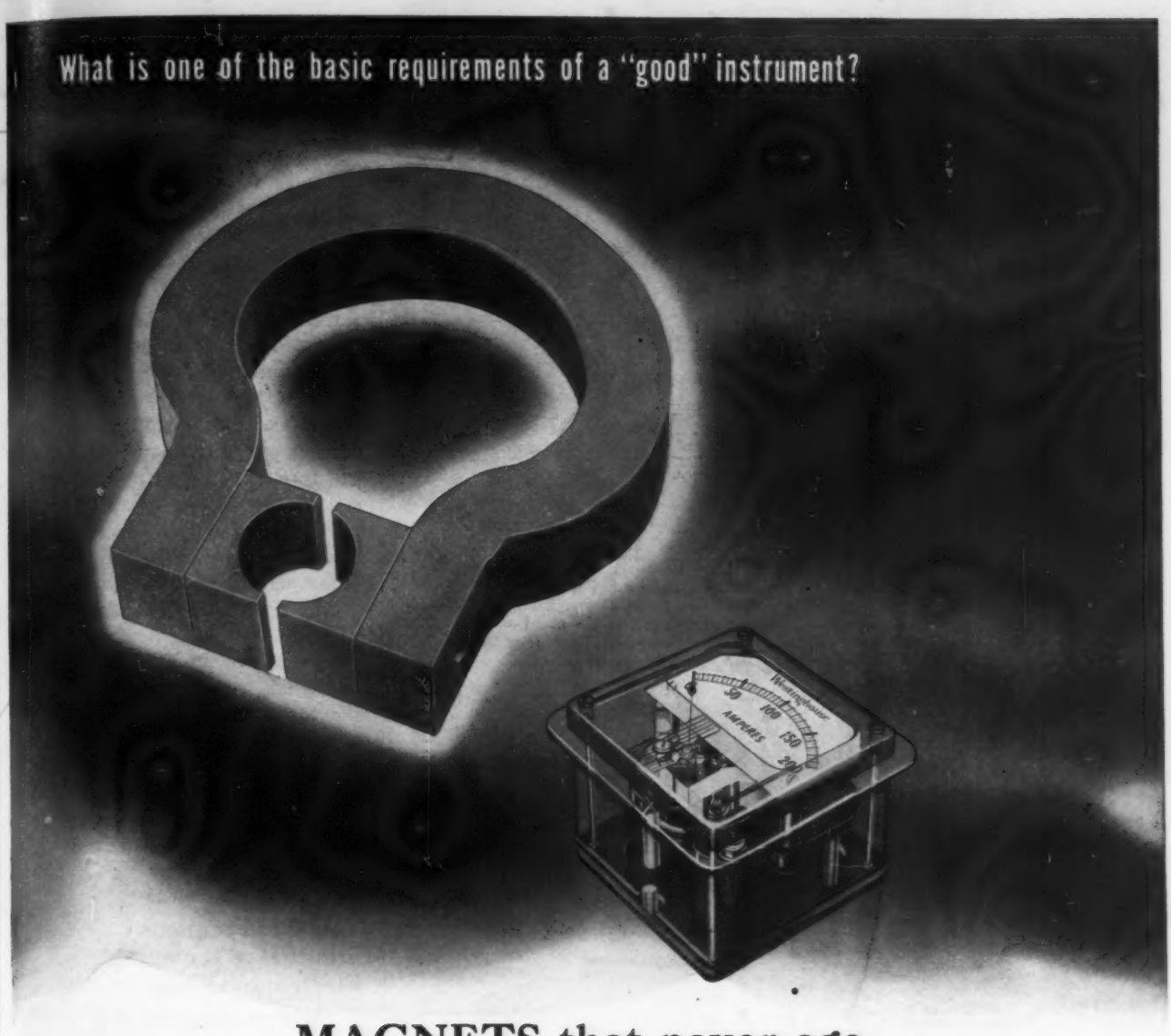


Signal and balancing circuits are kept separate in wiring; batteries for individual stages are on top of chassis with tubes and additional shielding

possible; a shield was put between stages. Input and output leads were kept well separated. The 6SN7 tubes were tested to obtain those having the least drift and being the least microphonic; the the 6SJ7 tubes were selected in matched pairs. Both amplifiers have performed very well for over two years.

Amount of drift depends largely on how closely the input tubes are matched and how long a warm-up is allowed. Because most of the drift is caused by change of cathode temperature, the heater current is turned on first. Tests with carefully selected tubes indicate that, after 10 minutes of warm-up, a drift equivalent to about 0.5 millivolt input signal can be expected over two hours. After the first hour, if no overloading has occurred, the equivalent drift has decreased to about 50 microvolts over a two hour period.

The frequency response is essentially flat from zero to at least 50,000 cps, and could be further extended if compensation in addition to the 85-mh inductance in the first stage were added. This inductance, wound on a high permeability iron core, reduces phase shift, which



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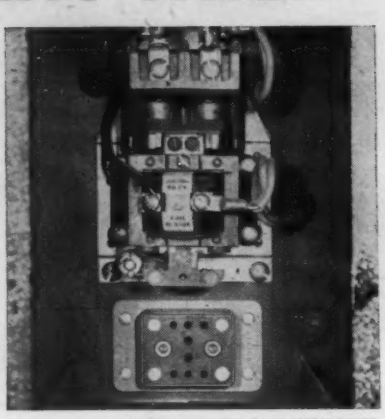
AUTOMATIC RECORDER, Type A301R, is equipped with Cannon Electric Type "K" Plugs and Receptacles. This instrument may be employed wherever multiple electric low-frequency phenomena, either periodic or transient, are to be recorded or studied.



UNRETOUCHED CANNON ELECTRIC PHOTO

ELECTRONIC UNIT in timer for die-casting machines equipped with Cannon Electric DPD Plugs. Panel portion is shown above. Rack unit plugs into the panel and carries pin insert assembly. Timer regulates die-casting interval automatically.

Plug-in with CANNON PLUGS

K-21 Plug

RK-24C Plug

TYPE "K"—made in 3 general shell types with nearly 190 insert arrangements available for a wide variety of wire sizes, including coaxials.

TYPE DPB — rack type pin and socket assemblies (both for rigid mounting) carry standard, coaxial and twinax contacts. Six basic lay-outs available in DPB, many more in the larger DPD size.

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comparison of input and output signals on an oscilloscope shows to be less than 10 degrees at 20,000 cps. The use of screen-grid tubes accounts for the high-frequency response with high gain because low plate resistances can be used without sacrificing amplification, as would be the case with triodes. This circuit lends itself to the use of screen-grid tubes, whereas in many d-c amplifiers their use is difficult.

The amplifier output is necessarily at a relatively high positive potential (150 to 200 volts) with respect to the input. Thus, only the input or the output, not both, can be grounded; the other must be well insulated from ground and handled accordingly. If the amplifier drives an oscilloscope, it is ordinarily more satisfactory to ground the output of the four stages shown in Fig. 2, allowing the final amplifier plates, which should be connected directly to the deflection plates of the cathode-ray tube, to assume a positive potential with respect to ground, and the input to the four-stage amplifier to assume a negative potential.

Variable-Frequency Stimulator for Electrophysiology

WALTER I. WEISS
Development Engineer
Rahm Instruments, Inc.
New York

IN MANY fields of biophysical and medical research, equipment for the electrical stimulation of living tissue is required. The stimulator to be described was designed to include a maximum of flexibility from all standpoints.

In general there are three variables to be considered, namely amplitude, waveshape, and repetition rate. All are interdependent from the standpoint of stimulation. The amplitude of stimulus required may be 3 to 5 volts for such applications as the location of motor areas of the brain in neurosurgery, or a few millivolts for the stimulation of the nerve in the gastrochemous muscle preparations.

Using this stimulator to contract the gastrochemous muscle of a frog by stimulation of the sciatic nerve, minimal stimulus was 12 millivolts

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Frequently, Stackpole Permanent Magnets of *Sintered* Alnico II mean both a worthwhile cost saving and an improvement in magnet efficiency. It all depends on such things as design, size, shape and weight.

In general, this Stackpole molded-sintering process offers its greatest economies in magnets up to 2 ounces in weight. Besides the production of rectangular and cylindrical types, the method extends to many odd shapes where costly machining is often eliminated.

Thus, to make it easy for quantity users to judge for themselves, we make this offer:

Send full details of your magnet requirements for recommendations and free samples to specifications (but not heavier than 2 ounces). Your own tests of these actual units will speak more convincingly than any mere claims we might make on their behalf.

STACKPOLE CARBON COMPANY • ST. MARYS, PA.

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SMOOTH SURFACES—for easier brazing or soldering.

CLOSE TOLERANCES—with a minimum of costly grinding.

FINE GRAIN STRUCTURE—for greater mechanical strength.

REAL ECONOMY, HIGHER UNIFORMITY—for odd shapes and small sizes.

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TRANSMISSION
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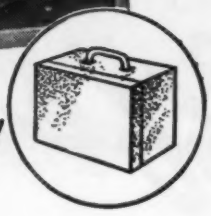


Completely Self-Contained
PORTABLE • AC OPERATED

With this instrument it is possible to quickly and accurately analyze and service equipment in different locations without fuss in time consuming demounting and transportation of apparatus. It will thus pay for itself in a short time and no modern radio station can afford to be without it. It can also be used to good advantage in factory checking and inspection of audio equipment.

The set combines in a modern efficient manner an accurate vacuum tube voltmeter, an audio oscillator with four fixed frequencies and a precision attenuator all mounted in a handy cabinet easily carried by the operator.

SPECIFICATIONS

- GAIN: Up to 80 db.
- LOSS: 60 db. maximum.
- VACUUM TUBE VOLTMETER: Range—40 to +40 db. (1 mv. ref. level)
- AUDIO OSCILLATOR: Freq. Range; 100 to 10,000.
- PRECISION ATTENUATOR: Flat to 20 KC; 93 db. in .1 db. steps.
- DIMENSIONS: 10¼" x 16¼" x 8¾"
- WEIGHT: 30 lbs.
- INPUT: 115 Volts. 60 cycles, 70 watts.

TECH LABORATORIES, INC.
Manufacturers of Precision Electrical Resistance Instruments
337 CENTRAL AVE. • JERSEY CITY 7, N. J.

for the sawtooth wave and 34 millivolts for the peaked wave at a basic repetition rate of 90 cycles per second and an ambient temperature of 26.6 C. The stimulator has a maximum output of 10 volts, while on the lowest of the three output ranges, variations of 2 millivolts can easily be set and read on the output meter. Continuously variable output is available over the entire range.

Choice of Waveshapes

Much has been said concerning the desirability of various wave shapes for stimulation, but as yet there has been no standardization, the choice being one of personal preference. Sinewave stimulators, both 60-cycle and variable-frequency, are in use to some degree. Rectangular waves have been used with success and there are many points in favor of this waveshape.

To date, however, little has been done in the development of a commercially available rectangular wave generator of sufficient flexibility. Perhaps the most widely used waveshape is the sawtooth, which is a close approach to the theoretically ideal exponentially rising voltage. Therefore, the sawtooth is one of the waveshapes included in the stimulator.

Making use of the linearizing circuit of Newsam, it is possible to obtain exceptionally good waveshape while at the same time increasing the efficiency of the thyratron to some 50 percent. In Fig. 1, cathode-follower stage V_2 is shunted across the greater portion of the charging resistor, R_4, R_5, and R_6. As the cathode to grid voltage is nearly constant for a cathode follower whose gain is nearly unity, the current

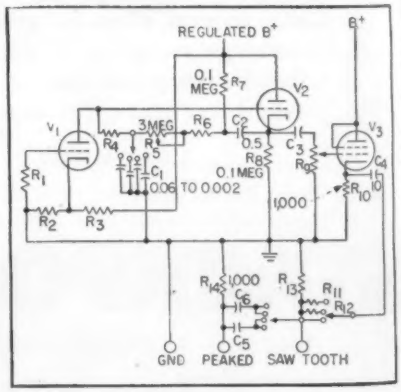


Fig. 1—Maximum output of 10 volts is provided by this electrophysiological stimulator

MIRAGLAS IS THE NAME

FOR THE 4 GRADES OF

4 VARNISHED TUBINGS

TO MEET OR EXCEED SPECIFICATIONS

SET BY VARNISHED TUBING ASSOCIATION AND AMERICAN SOCIETY FOR TESTING MATERIALS

STANDARD GRADE

for maximum flexibility, has little varnish and is recommended for high temperatures where dielectric strength is not a factor.

DOUBLE SATURATED

has all qualities of the STANDARD GRADE but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

TRIPLE STRENGTH

is built up with coats of especially flexible insulation varnish for dielectric ratings up to 2500 volts and is particularly suited where assembly operations include the possibility of rough handling.

IMPREGNATED

is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 7000 volts and is unequalled for Long Life Under Most Severe Conditions. *Write For Samples.*

FOR USERS OF COTTON YARN VARNISHED TUBINGS The Mitchell-Rand MIRAC and HYGRADE Varnished Tubings of long staple fiber yarn are comparable to Fiberglas Tubings in dielectric ratings, tensile strength, flexibility and long life.

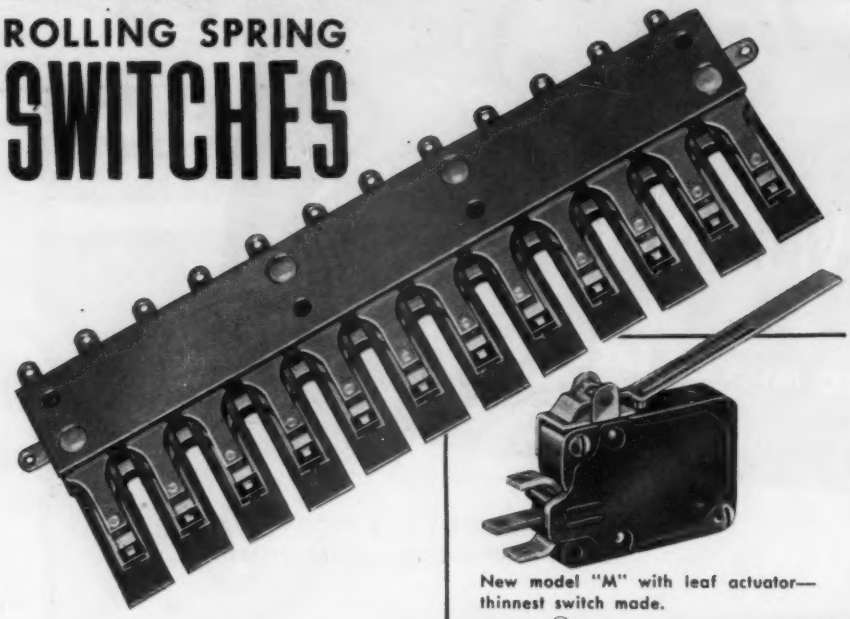
Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drills, etc.

MITCHELL-RAND INSULATION CO. Inc.

51 MURRAY STREET · COrtlandt 7-9264 · NEW YORK 7, N. Y.

A PARTIAL LIST OF M-R PRODUCTS: FIBERGLAS VARNISHED TUBING, TAPE AND CLOTH · INSULATING PAPERS AND TWINES · CABLE FILLING AND POTHEAD COMPOUNDS · FRICTION TAPE AND SPLICE · TRANSFORMER COMPOUNDS · FIBERGLAS SATURATED SLEEVING · ASBESTOS SLEEVING AND TAPE · VARNISHED CAMBRIC CLOTH AND TAPE · MICA PLATE, TAPE, PAPER, CLOTH, TUBING · FIBERGLAS BRAIDED SLEEVING · COTTON TAPES, WEBBINGS AND SLEEVINGS · IMPREGNATED VARNISH TUBING · INSULATED VARNISHES OF ALL TYPES · EXTRUDED PLASTIC TUBING

Come to ACRO for ROLLING SPRING SWITCHES

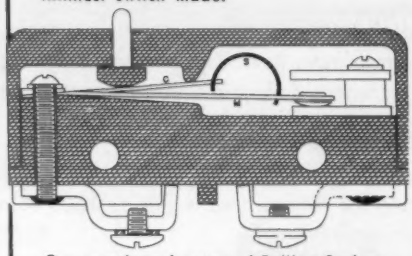


New model "M" with leaf actuator—thinnest switch made.

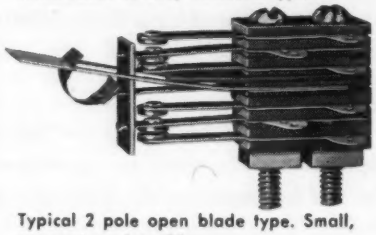
...precision engineered TO FIT THE JOB

Let us engineer and build your Snap-Action Switches to meet the engineering requirements of your application. ACRO Switches are also built in gangs (as shown above) in any number for your economical assembly.

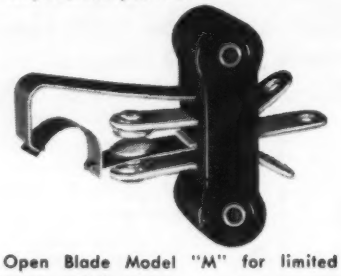
All ACRO Snap-Action Switches are designed with the famous patented Rolling Spring principle that assures more POSITIVE action, longer life, and greater economy. Single pole or multiple pole. Normally open, normally closed, or double throw. Variety of actuators. Fully enclosed and open blade types. Operating characteristics to suit your needs. Ratings: Up to 15 Amps, 125 Volts A.C. Send blueprints and details for quicker action.



Cross section of patented Rolling Spring construction in fully enclosed type.



Typical 2 pole open blade type. Small, compact, and positive.



Open Blade Model "M" for limited space and low cost.

ACRO ELECTRIC COMPANY
1316 SUPERIOR AVENUE, CLEVELAND 14, OHIO

through the resistor is almost constant and capacitor C_1 charges linearly.

Distortion is further minimized by the use of cathode-follower output stage V_3, which serves as an impedance transformer to the low output impedance. This low value is a requisite for good regulation since the preparations to be stimulated are apt to be low-impedance loads.

A second wave shape is available by differentiation of the sawtooth wave. The resultant sharp pulse is often of use when a stimulus of short duration is desired. It may also be used simultaneously with the sawtooth to trigger a single sweep circuit for observation on a cathode-ray oscilloscope. The output meter reads approximately the average value of the sawtooth wave and is calibrated in equivalent rms value for sinusoidal voltage.

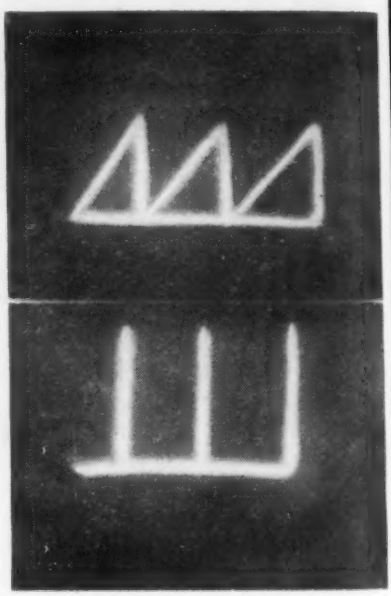


Fig. 2—Sawtooth and pulse output wave shapes of the electronic stimulator as seen on a c-r tube

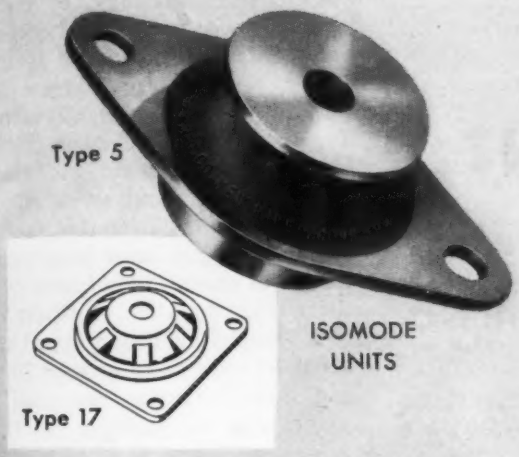
The frequency is determined by charging resistor R_5 and capacitor C_1. It is felt that the range incorporated, 11.5 to 1,300 cycles per second, is more than sufficient to meet most electrophysical requirements. Good frequency stability for line voltages from 95 to 125 volts is obtained by use of a regulated voltage supply for the oscillator section.

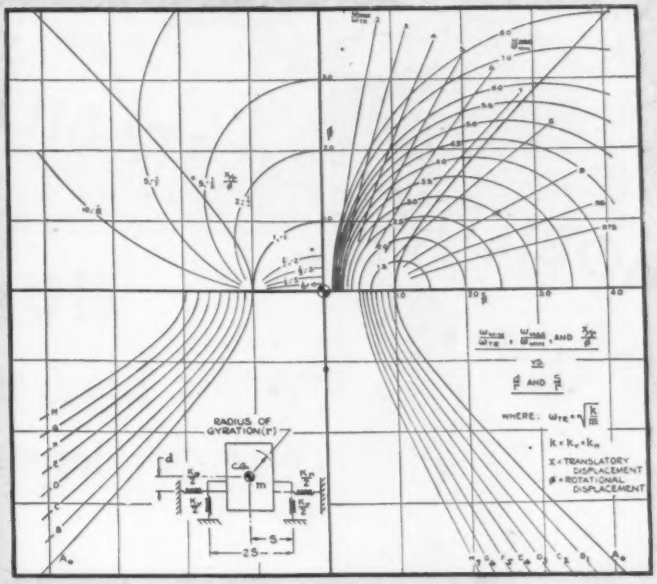
A 600-volt, hermetically sealed, oil-filled capacitor is used to couple the cathode of output stage V_3 to output resistor R_{13}. The instantane-

GREAT NEWS!

VIBRATION CONTROL now SIMPLIFIED

...with MB developments in vibration engineering





ISOMODE DESIGN CHART

HERE'S A REMARKABLE, new method of locating support points for flexible mountings. It reduces your difficult design problem to an almost routine job. And what's more, it assures you *optimum* isolation every time, from standard units, with mathematical certainty! Here are partial details:

THE MB ISOMODE* DESIGN CHART SAVES WORK, SAVES TIME

Set down graphically are the relationships you formerly found by trial and error. Each quadrant covers a different phase of the entire vibration problem. You outline your product right onto the chart. Then read your solutions directly from intersections of various curves and mount-locations of product.

SEND FOR FREE REPRINT

This technical paper gives the information you need for better vibration control design. It describes the chart—shows you how to use it. No obligation, of course. Write Dept. B5

THE MB ISOMODE* UNIT— CLINCHES THE RESULTS

You can install these units at any convenient angle—because MB engineered them with an equal spring rate in all directions. That's also why they isolate with extra high efficiency. For the same radial and axial softness absorbs not only vertical, but *horizontal* and *rocking* motions as well! They have high deflection capacity, yet are thoroughly stable. Safe, self-snubbing, compact sizes are available for loads of ½ pound to 2500 pounds.

Why not investigate this simplified MB method? Give your product the benefit of vibration control accomplished in the *design stage*—and make no compromise on efficiency. You'll get a product that works more smoothly, lasts longer—and sells better!

*Trade Mark Reg. U. S. Pat. Off.

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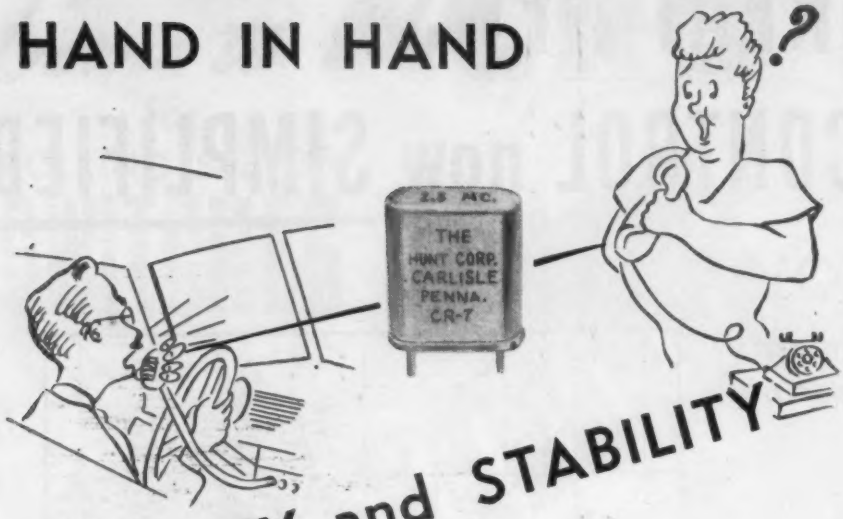
New Haven 11, Conn.
VIBRATION ISOLATOR UNITS • VIBRATION TEST EQUIPMENT

VIBRATION DIVISION

HAND IN HAND



MOBILITY and STABILITY

HUNT

crystals play their part in new developments

Here's the problem—Wilcox Electric Company, Kansas City, Mo., required in its new Mobile Radio Telephone Set high stability, low power consumption and shock resistance.

Here's the solution—The Hunt Corporation's specially developed CR-7 crystal units for this application. These crystals are shock proof and the stability built into them eliminates the need for power-consuming ovens.

WILCOX Electric Company, one of the country's leading manufacturers of radio equipment, is now in production on one of its latest developments—the Mobile Radio Telephone Set. For the crystal units needed to assure the best possible results from the "Telephone on Wheels" . . . Wilcox turned to The Hunt Corporation, manufacturer of high stability, close tolerance crystals.

For the crystals you need to give better results from your set, get together with Hunt engineers . . . Do it today.

THE Hunt CORPORATION
CARLISLE, PA.

Pacemaker in Stability

ous peak voltage is never more than 50 volts.

Examples of output waveshape, both sawtooth and pulse, are given in Fig. 2. A switching arrangement is provided externally to allow for keying of the stimulus in applications where continuous stimulation is not desired.

SURVEY OF NEW TECHNIQUES

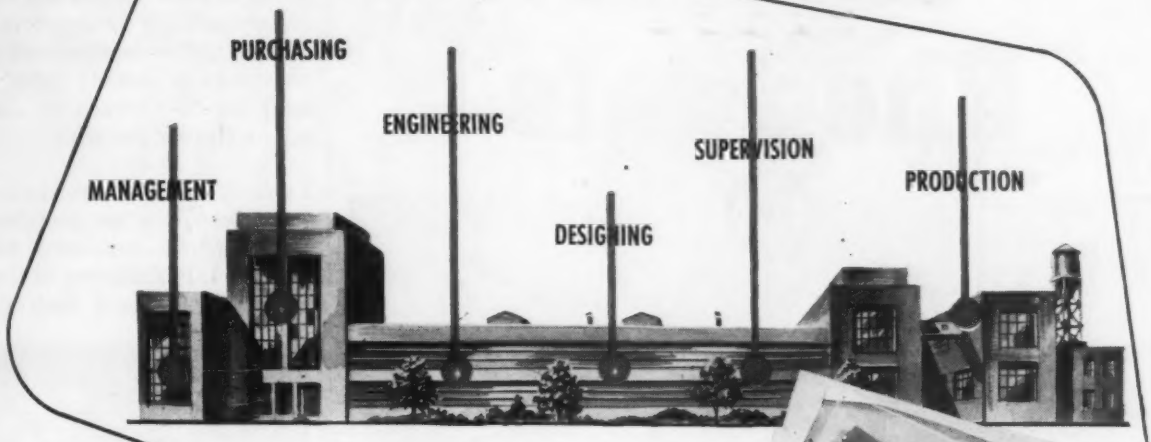
ELECTRONARCOSIS, electrically induced sleep, is a modification, developed by scientists working with Dr. K. M. Bowman at California Institute of Technology, of electroshock. It is being tried out clinically in the California State Hospital under research funds from University of California. Treatment for some forms of insanity, consisting of applying current through electrodes for about seven minutes as shown in the illustration, is given on an empirical basis pending collection of enough case histories for thorough evaluation. Initially 170 to 250 ma are applied, dropped after about 30 seconds to around 70 ma, and then gradually increased depending on the patient's reactions.

Electrical shock therapy may cure some forms of insanity

In the Glissando technique, reported by Dr. E. B. Tietz of Los Angeles, the current is stepped up during the first few seconds from zero to the initial dosage. The patient returns to consciousness shortly after the current is removed.

COLD-CATHODE RECTIFIERS in which a corona discharge at atmospheric and higher pressures of hydrogen and nitrogen were found to be useful for low-current applications by W. H. Bennett, now at the National Bureau of Standards. Discharge is produced from the tips of wires of

Where Sales are made . . .



you'll find electronics BUYERS' GUIDE

. . . on the desks of the engineers and executives throughout industry—those all-important men whose decisions and plans are the final factors in the purchase of electronic components, "packaged" equipment, or allied products.

These men have learned to rely on, and use the Buyers' Guide for information on product sources *and* technical data on those products. A handy desk package for the time-pressed designers—the only directory of its kind—containing accurate information on all products concerned with their work. When they look up a needed component or product and find one with correct characteristics—a sale has been made.

As a matter of fact, that is your Point of Sale. Once a product has been designed into the pilot model the time for selling, 9 times out of 10, is passed. It is either too late or too difficult to change or fit in a substitute. Don't overlook this year round salesman—be sure to include it in your 1948 advertising budget.

THE MEN YOU MUST REACH . . .

If you are going to sell your product, the best time to reach them is when their product is on the drafting table and components or complete equipment is being designed in. That's the point of sale—and it's the time they're using the Buyers' Guide.

electronics
BUYERS' GUIDE

The reference buying guide used by every industry

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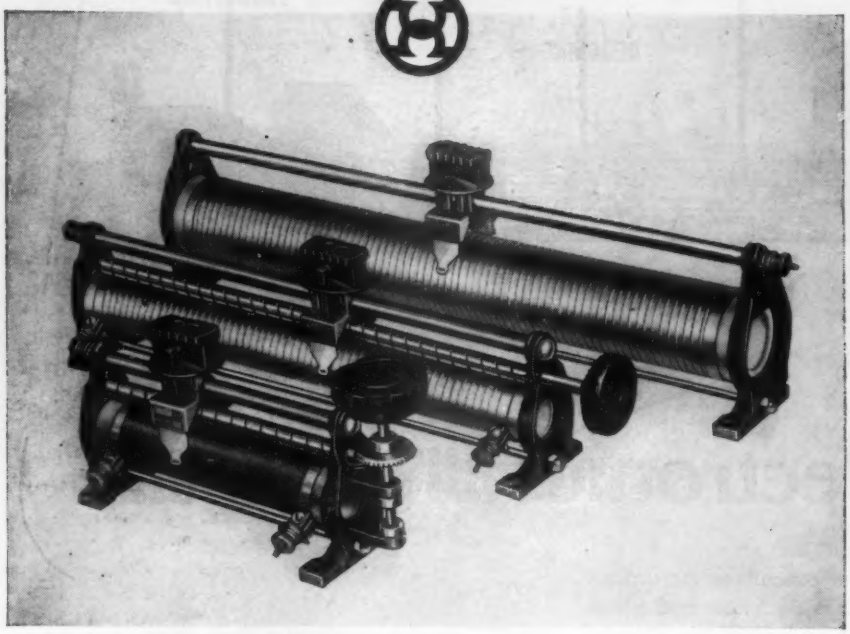
HARDWICK, HINDLE
Tubular Rheostats



THESE FINE SLIDING contact rheostats are widely used in laboratories. They serve as rheostats or potentiometers;—portable, easily mounted, with fine gradations of adjustment.

These sturdy, improved tubular rheostats are used for accurate adjustment of voltage or current in meter-checking laboratories; —as field rheostats for generator and motor control;—as filament and plate control in radio and audio transmitting and amplifying apparatus;—for control of illumination and heat control in electric furnaces and ovens; as well as in general laboratory use.

Available in 3 sizes: 200, 400 and 750 watts with any one of 3 types of control.

Hardwick, Hindle resistors and rheostats offer many exclusive advantages. We ask you to give our engineers an opportunity to discuss your specific requirements.

HARDWICK, HINDLE, INC.

Rheostats and Resistors

Subsidiary of

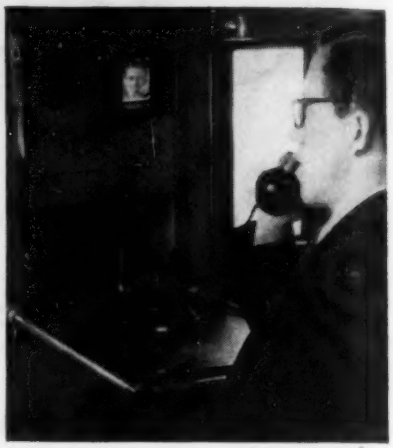
THE NATIONAL LOCK WASHER COMPANY

NEWARK 5, N. J. Established 1886 U. S. A.

ELECTRON ART (continued)

0.4 to 3 mils diameter. Atmospheres free from electron attaching components are necessary. Anodes in the tubes can be formed by coating the envelope with Aquadag. As the tubes require no heater, they can be conveniently arranged in a voltage-multiplier rectifier and require no warm-up period; tubes can be built for 10 kilovolts at about 100 microamperes per wire.

VIDEOTELEPHONE comprising a small television set combined with the telephone apparatus has been built by I. P. Zakharov of the USSR Television Research Institute. The



Telephone position includes lighting, iconiscope (behind round dark opening), and kinescope (in recessed box)

equipment, showing the person at the other end of the line, is installed at the Institute.

VELOCITY OF PROPAGATION of centimeter radio waves must be accurately known in making range measurements by radar. Measurements directed by F. E. Jones of the British Telecommunications Research Establishment and conducted over clear optical paths up to 40 miles long over sea show that the velocity of propagation is 186,217 ± 16 miles per second, which is substantially the velocity computed by taking into consideration the refractive index of the atmosphere. The measuring technique consisted of accurately surveying the distance between two sites, measuring the radio time between them with oboe blind-landing radar range equipment (9 cm) whose timing and sweep had been accurately calibrated, and computing the wave velocity.

one-two-three! insert engage actuate!

3 simple steps to fast, secure fastening with **CHERRY** blind rivets

ONE MAN REPLACES TWO. Bottom of soda fountain shows Cherry Rivets. Body fastened with self-plugging rivets, foot with pull-through hollow rivets. One man does a fast, secure job.

IT'S JUST THAT SIMPLE. Insert the Cherry Rivet in the hole, engage the rivet, actuate the gun. A powerful controlled pull does the rest. This adds up to speed, speed, speed.

DYNAMIC EXPANSION of the rivet shank during installation means tight, strong, vibration-resistant joints. One man does it all. No bucking bars, no hammering. Just three simple steps to fast, secure fastening.

SCREWS WORK LOOSE. Cherry Rivets replace sheet metal screws in construction of refrigerated creamery trucks at Los Angeles Automotive Works. Screws had a bad record: 60% of screws would work loose within 6 months. Cherry Rivets have a perfect record of tight, vibration-resistant joints.

Tight-clinching pull-through hollow type Cherry Rivet

High strength self-plugging type Cherry Rivet

For more information write to Dept. J-120, Cherry Rivet Co., 231 Winston Street, Los Angeles 13, Calif.

CHERRY RIVETS, THEIR MANUFACTURE & APPLICATION ARE COVERED BY U.S. PATS. ISSUED & PEND.

VIBRATION DOESN'T MATTER NOW. Screws and bolts used to work loose when the stoves were in transit. So J. H. McKie Co. now fastens stove frames with Cherry Rivets. Fast production. Tight, vibration-resistant joints.

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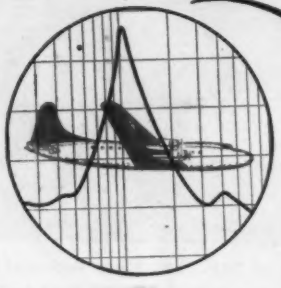
TOROIDAL COIL FILTERS

for every application

Our toroid filters have become a by-word in every phase of electronics where only the best results are acceptable. Toroidal coils wound on MOLYBDENUM PERMALLOY DUST CORES are the primary basis for our success in producing filters unexcelled in performance.



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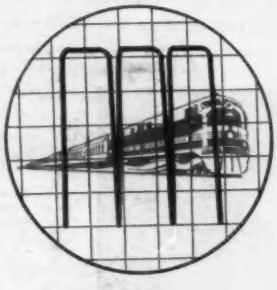
Radio control—miniaturizing —Aircraft. Nuclear research.



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Multi channel filters for carrier modulation.

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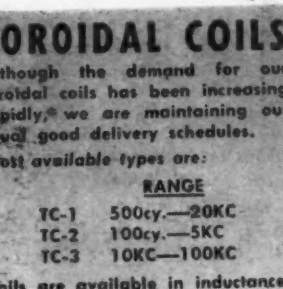
Tone keying filters — wave shaping filters — discriminators — delay networks.



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Line filters—slope equalizers loading circuits.

We would be pleased to submit quotations for special filters.

Write for our catalogue.

TOROIDAL COILS

Although the demand for our toroidal coils has been increasing rapidly, we are maintaining our usual good delivery schedules.

Most available types are:

	RANGE
TC-1	500cy.—20KC
TC-2	100cy.—5KC
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Coils are available in inductances from 1 MHY to 12 HYS.

Burnell & Co.

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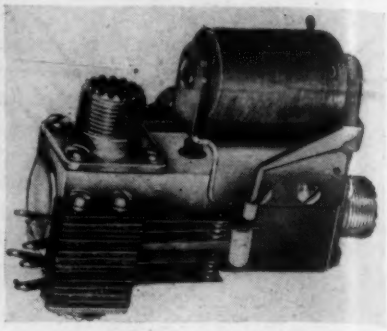
YONKERS 2, N. Y.

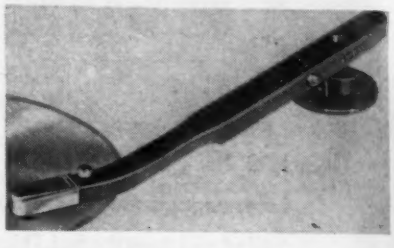
NEW PRODUCTS
(continued from p 142)



lines. An inspection port is provided for the internal contacts, and external contacts are available for the control of indicator lights or associated circuits. Connectors are Amphenol 83-1R for RG-8U coaxial cable.

Reproducer (13)

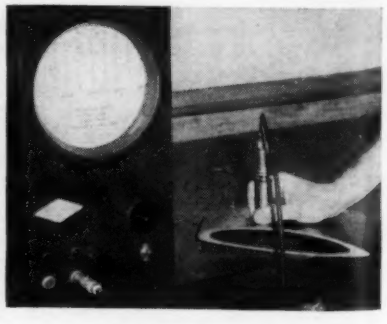
AUDAK CO., 500 Fifth Ave., New York, N. Y. Model 74-A tuned ribbon reproducer has high output without amplification. The jewel



stylus can be replaced by the user. Response is linear to 10 kilocycles. Pressure is 24 grams.

Ultrasonic Gage (14)

SPERRY PRODUCTS, INC., 15th St. and Willow Ave., Hoboken, N. J. The Reflectogage is an ultrasonic thickness-measuring device that requires access to only one side of the material. It measures thickness of tubes and flat parts directly in the range 0.005 to 0.300 inch, or indi-



Millions of knobs to prove one thing about plastics

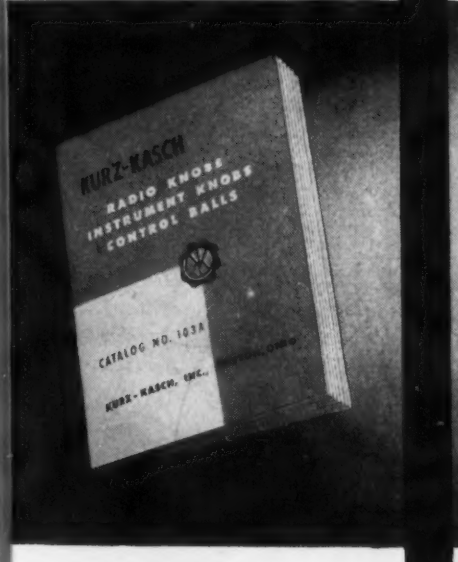
KURZ-KASCH FOR STANDARD KNOBS

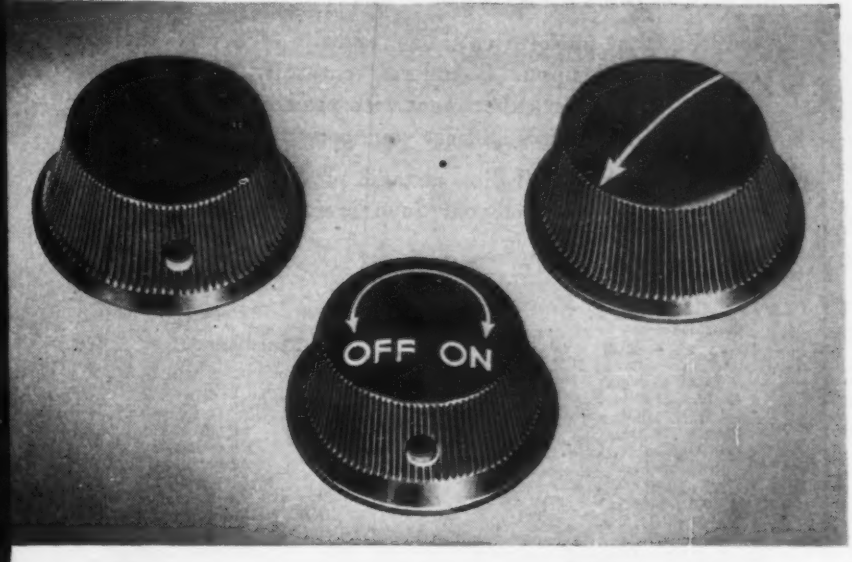
A functionally clean and logical design, this knob has served radio, electrical and other industries for over a generation. It has been an indicator control on everything from kerosene stoves to mammoth panel-boards and airplane cockpits. It and its many companion radio, instrument and pointer knobs have made Kurz-Kasch the foremost source of standard plastic knobs in America. For full details, send for the newly-revised Catalog 103A.

Good plastics applications pay off—especially when they are designed with an eye on the years ahead. By "good applications", we mean those that improve products quality-wise or cost-wise—or by supplying special characteristics. There's not much future for plastics used otherwise, for you or your moulder.

For example, we built the first mould for these control knobs 25 years ago. They proved immediately popular, and have continued throughout the years to be a top-selling standard item—so much so that three additional moulds were quickly built to satisfy demand. We've produced million after million of them *from these four original moulds.*

Whether it's a stock or custom job up for consideration, we pride ourselves at Kurz-Kasch on correct plastics applications designed and engineered *to get the most out of initial mould costs.* We maintain that it is the long-running job proving the foresight and capabilities of the established custom moulder that really expresses the plastics industry's bid for the future.





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WHAT MAKES A *Masterpiece in a*
RECORDING . . .

Critical recordists everywhere are discovering that uniform cutting properties of Soundcraft discs can be relied upon. Soundcraft carefully guards its fine quality — does not experiment with production. Standardize on standardized discs and get your program *every* time.

Ask for Soundcraft discs at radio parts distributors in principal cities or contact your Soundcraft representative listed.

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105 Forrest Ave., N.E.
Atlanta, Georgia
Walnut 8246

Emmett N. Hughes
1709 W. Eighth St.
Los Angeles 14, Calif.
Exposition 1169

W. F. Lowry
3239 Faronia St.
Pittsburgh 4, Pa.
Walnut 2959

H. E. Walton Co.
2111 Woodward Ave.
Detroit, Michigan
Cherry 6460-1

J. E. McKinley
401 No. Broad St.
Philadelphia 8, Pa
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Land-C-Air Sales, Inc.
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14 Pearl Street
New York 4, N. Y.
BO 9-9238

B. L. MacPherson Co.
601 Fort Wayne Bank Bldg.
Fort Wayne 2, Indiana
Anthony 9460

R. Fred Brown
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Westmount, Montreal,

Patterson & Co.
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Dallas 1, Texas
C-5764

Northwestern Agencies, Inc.
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Eliot 8882

John O. Olsen
1456 Waterbury Road
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Anthony C. Wahl
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• The 'Broadcaster' 8" 10" 12" 16"
• The 'Playback' 6½" 8" 10" 12" 16"
• The 'Audition' 6½" 8" 10" 12" 16"
• The 'Maestro' 12" 13¼" 17⅛"

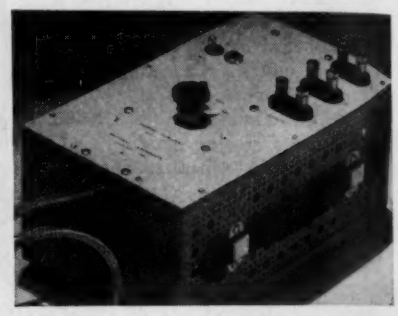
Soundcraft

REEVES SOUNDCRAFT CORPORATION
10 EAST 52 STREET • NEW YORK 22, N. Y.

rectly up to several inches. Bore eccentricity or lack of bond can also be detected. Typical materials on which the gage can be used are steel, brass, silver, copper, aluminum, magnesium, and glass, as well as certain plastics and rubbers.

Instrument Amplifier (15)

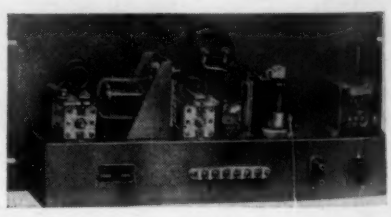
KEITHLEY INSTRUMENTS, 1508 Crawford Road, Cleveland 6, Ohio. Phantom Repeater model 102 is essentially an instrument amplifier with a high-impedance input, used to bridge measuring instruments across high-impedance circuits, give simultaneous indication of voltage, waveform, and aural tone,



and increase the sensitivity of voltmeters and cathode-ray oscillographs. The device has an input of better than 200 megohms and 5.5 micromicrofarads.

H-F Transmitter (16)

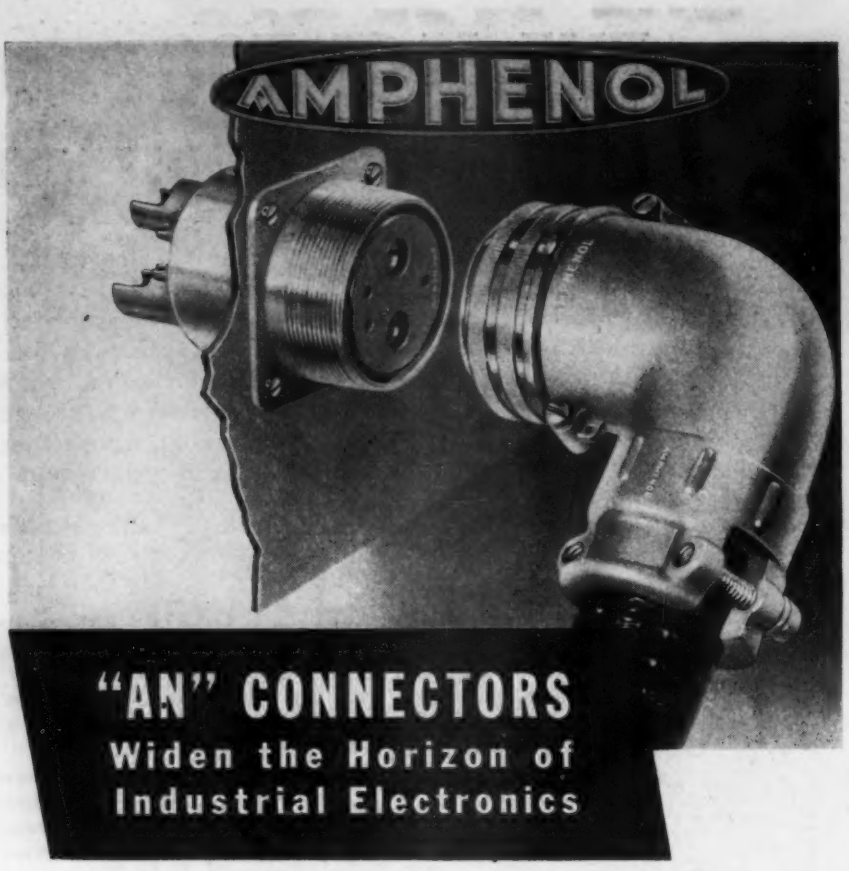
JAMES MILLEN MFG. CO., INC., Malden, Mass. A new high-frequency transmitter with output on the 10-11, 6, and 2 meter amateur bands is



crystal controlled by means of a newly developed Bliley unit. The final uses an 829B tube with 100 watts plate input.

VR Tube Checker (17)

WESTON ELECTRICAL INSTRUMENT CORP., 617 Frelinghuysen Ave., Newark 5, N. J. Model 798 Type 5



"AN" CONNECTORS
Widen the Horizon of
Industrial Electronics

Wherever industrial electronic equipment is sectionalized, Amphenol AN connectors serve with efficiency and economy to provide quick connection and easy disconnect for servicing or movement.

They save money by permitting associated wiring for one or many circuits to be prefabricated, thus electronic devices may be tested at the factory and instantly connected for use on arrival. This greatly simplifies installation and servicing procedures.

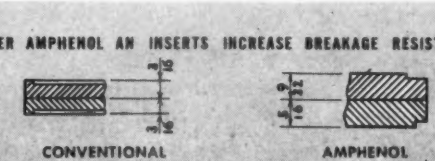
Available in five major shell designs, each of which accommodates over 200 styles of contact inserts, Amphenol AN connectors handle voltages up to 22,000, amperages up to 200. Types with pressure-proof, explosion-proof or moisture-proof housings also are available, as are standard elements for thermocouples.

Amphenol, long the leader in mass-producing AN connectors for the armed forces, remains completely tooled for large-scale production for industry at costs far below those in effect pre-war. Write for full data now.

AMERICAN PHENOLIC CORPORATION
1830 South 54th Avenue, Chicago 50, Illinois
COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RADIO COMPONENTS • PLASTICS FOR ELECTRONICS

AMPHENOL

THICKER AMPHENOL AN INSERTS INCREASE BREAKAGE RESISTANCE

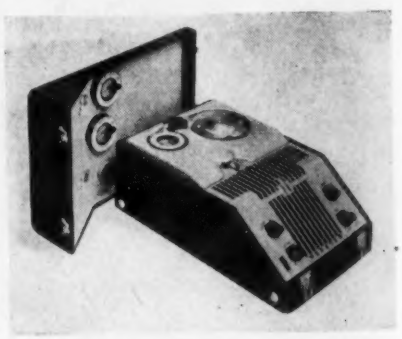


Here's another example of the "safety insurance" supplied by alert Amphenol engineering: On all sizes, from 20 up, Amphenol inserts are thicker, offering greater resistance to breakage. This is particularly important where larger diameters are employed, and a greater number of contacts accommodated.

proportional mutual conductance tube checker tests all receiving tubes as well as voltage regulators and low-power thyratrons. Three signal voltages of 0.75, 1.5, and 3 volts provide mutual conductance ranges of 12,000, 6,000, and 3,000 microhms without danger of damage to the tube under test. Sixty cycle a-c is used on the tube elements and a separate 5-kilocycle signal is applied to the control grid. The resulting plate component of the high-frequency signal is measured on a rectifier meter.

Wire Recorder (18)

WEBSTER-CHICAGO CORP., 5610 Bloomingdale Ave., Chicago 39, Ill. Model 80 wire recorder is completely selfcontained, comprising recording and playback amplifier, loudspeaker, microphone and three



spools of wire in a carrying case. Price of the unit, east of the Rockies is $149.50. Additional wire costs from $2.40 to $6.45 depending on whether a 15-minute, half-hour or full-hour spool is purchased.

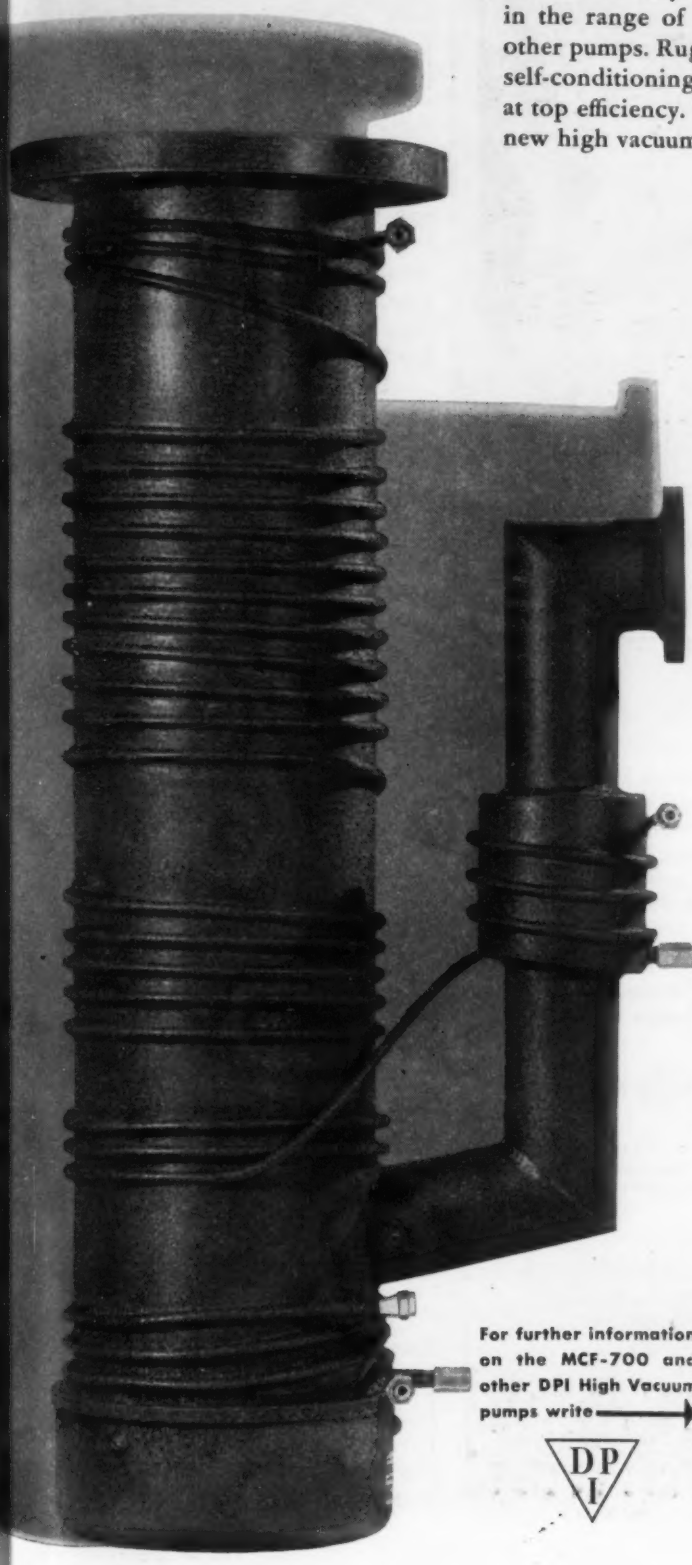
Insulation Tester (19)

RADIO FREQUENCY LABORATORIES, INC., Boonton, N. J. A new tester developed for measuring insulation resistance of power cables, transformers, and other components up

For New High Speeds in the Lower Pressure Ranges—

THE MCF-700 HIGH VACUUM PUMP

WHEN you need high pumping speeds in pressures down to 10^{-6} mm of mercury, the performance of the new MCF-700 will meet your specifications exactly. This pump delivers from 100 to 500 liters per second in the range of 10^{-6} to 10^{-5} mm, — performance unduplicated by any other pumps. Ruggedly constructed, the MCF-700 operates on a unique, self-conditioning principle which keeps the fractionating jets operating at top efficiency. The tables below outline the essential features of this new high vacuum pump.



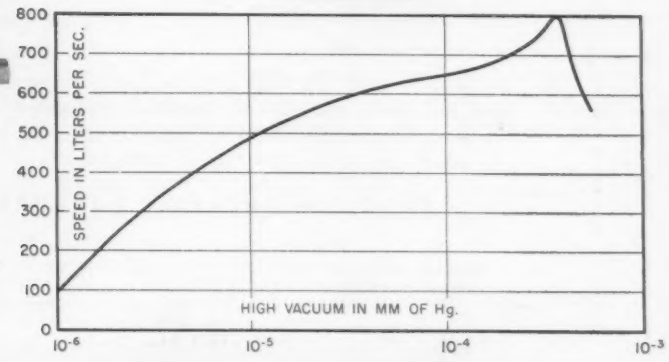
PHYSICAL DATA

High Vacuum Flange	6″ i.d., 9″ o.d. 8″ bolt circle
Forepump Flange	2⅜″ i.d., 3¾″ o.d. 3 5/16″ bolt circle
Height	29″
Length	14″
Width	9″
Construction:	
Casing	Seamless Steel
Jet Assembly	Aluminum and Steel
Cooling	Water
Weight	Approx. 40 lbs.

OPERATION DATA

Amount of Oil	500 grams
Recommended Oil	Octoil or Octoil-S
Forepressure	0.10 mm
Heater Power	800 watts
Heater Current	7.0 amp.
Heater Voltage	115 volts A.C. or D.C.
Speed	700 l/s
Ultimate Vacuum	5×10^{-7} at 25° C.

PERFORMANCE



For further information on the MCF-700 and other DPI High Vacuum pumps write →

DP I

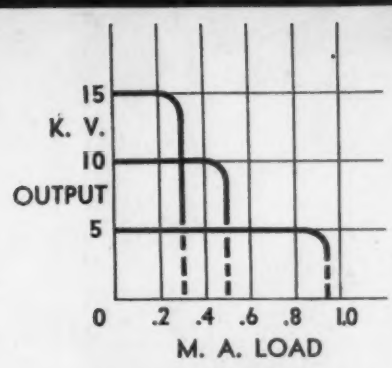
Vacuum Equipment Division

DISTILLATION PRODUCTS, INC.

Rochester 13, N. Y.

FREQUENCY-MODULATED PULSED POWER SUPPLIES

adjustable from 0 to full output



A new regulation principle for pulsed power supplies results in the regulation curves shown at the left.

Additional Features

Light-Weight — Model 501-E, 0 to 15 KV, weighs 23 lbs. Housed in compact cabinet 9″ x 7″ x 15″.

Safe — High operating frequency permits use of low filter capacitances. Inherent sharp cut-off at overload protects circuit components and personel from short-circuits.

Output Kilovoltmeter — Full scale accuracy of 3%.

Low Power Consumption — 65 V.A. from 115 V, 60C line.

Also available in 0 to 30 KV range

Model 501-E

Other BETA instruments include:

MODEL 301 ELECTRONIC MICROAMMETER: Cannot be damaged by any degree of overload. Full scale ranges from 0.01 microamperes to 100 microamperes.

SERIES 101 KILOVOLTMETERS: 50,000 ohms per volt instruments, 20 microamperes full scale drain, available in ranges up to 50 KV. Portable, compact, safe. Can be used without turning off high voltage to connect meter.

MODEL 201 — 0 TO 30 KV DC POWER SUPPLY: A portable, rectified 60 cycle power supply. Variac controlled. Currents up to 2 m.a. may be drawn.

High voltage power supplies up to 150 KV made to your specifications.

for further information, write or wire to:

Beta Electronics Company Equipment *has been purchased by the following:*

Bell Telephone Labs.
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U. S. Navy
Massachusetts Institute of Technology
Douglas Aircraft Co.
Northern American Philips Co.
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American Cyanamide Co.
Sylvania Electric Co.
Winchester Repeating Arms Co.
Harvard University
G. D. Searle & Co.
U. S. Television Corp.
University of California at Los Angeles
and others

BETA ELECTRONICS COMPANY

Dept. E-O 1762 Third Avenue New York 29, N. Y.

SALES REPRESENTATIVES IN ALL MAJOR CITIES

Silent and chatterless

...just like an Adlake Relay!

Silent, positive action is just one of *many* Adlake Relay advantages!

Other important ones are:

- Hermetically sealed contact mechanism—impervious to dust, dirt and moisture.
- Liquid mercury-to-mercury contact —no burning, pitting or sticking.
- Armored against outside vibration or impact—designed for either stationary or moving equipment.

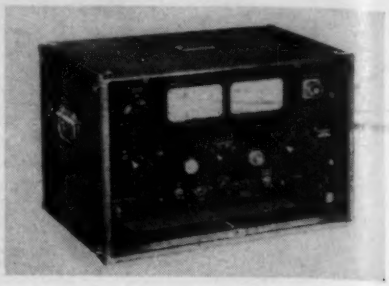
Remember, *whatever* your relay needs may be, there's an *Adlake* Relay to do the job. So write today for free, illustrated folder. No obligation, naturally. Address: The Adams & Westlake Company, 1107 N. Michigan, Elkhart, Ind.

ADLAKE RELAY MODEL NO. 1040

THE Adams & Westlake COMPANY

Established 1857 • ELKHART, INDIANA • New York • Chicago

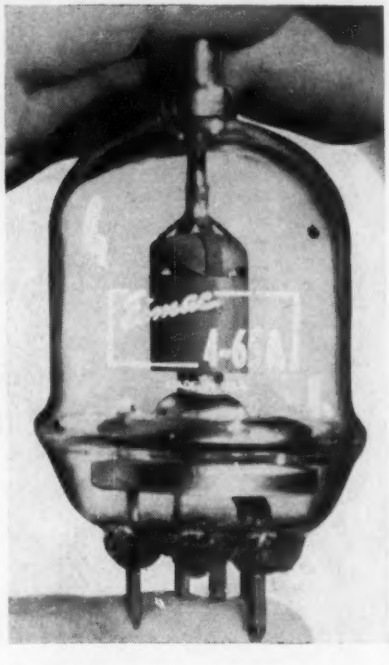
Manufacturers of Adlake Hermetically Sealed Mercury Relays for Timing, Load and Control Circuits



to 10 kv is arranged for rapid operation. Breakdown voltages can be determined with a minimum of damage. Full manual control allows selection of desired output voltage. Safety to personnel and equipment is insured in the design.

Low-Power Tetrode (20)

EITEL-MCCULLOUGH, INC., San Bruno, Calif. Availability of the new type 4-65A low power tetrode using a 6-volt thoriated tungsten filament has just been announced.

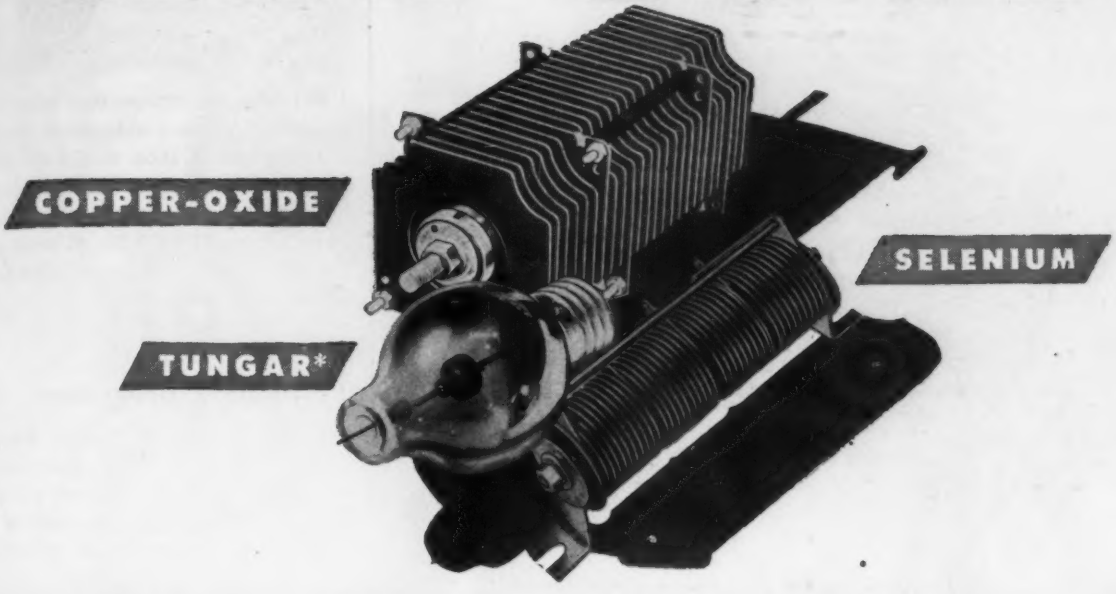


Good performance is obtained well above 200 mc and a single tube operating at 2,000 volts will provide 200 watts of power output in Class C or f-m telephony service. The tube is priced at $14.50

Variable Capacitor (21)

NORTH AMERICAN PHILIPS CO., INC., 100 East 42nd St., New York 17, N. Y. A new air-dielectric variable capacitor with a range of 30 to

ALL GOOD



but which is best for you?

Do you need a source of d-c, where space and allowable weight must be held to a minimum? General Electric has the answer . . . a selenium rectifier.

Must equipment operate where it is subject to intermittent overloads of short duration? The answer will probably be a copper-oxide rectifier.

Perhaps exceptionally low cost is the most important requirement . . . then you will want to consider General Electric Tungar rectifiers.

But, regardless of what application you have in mind, your first step should be to consult a General Electric rectifier specialist. With his years of practical experience with the only manufacturer of all three basic types of low-voltage rectifiers, he is thoroughly qualified to give you impartial advice.

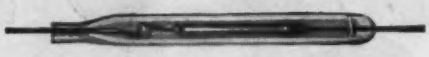
After considering all factors such as size, weight, performance characteristics, and cost that affect your designs, the General Electric engineer can readily determine the best rectifier for you.

Why not take advantage of our engineering service now? There is no obligation. Just ask your local General Electric representative to call, or send your problem to Section A98-1031, General Electric Company, Bridgeport 2, Connecticut.

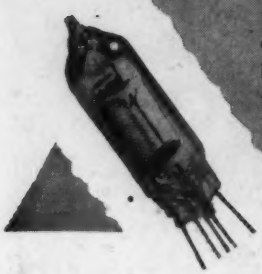
**Trade-mark Reg. U. S. Pat. Off.*

GENERAL ELECTRIC Rectifiers

Quality components are essential to the measurement of radiation



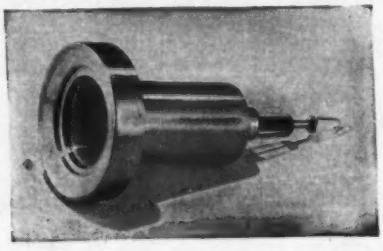
Victoreen Hi-Megohm resistors in a range of values from 100 megohms to 10,000,000 megohms fill an urgent need in the production of sensitive instrumentation. Unusual stability with low voltage and temperature coefficients within the recommended operating ranges. Vacuum sealed in glass with special surface treatment.



A new low microphonic feature recently incorporated in the VX series of subminiature electrometer tubes takes its place beside such other characteristics as filament current of 10 ma. and grid resistance of better than 1015 ohms which are unobtainable in any other tube. Designed to make fine instrumentation even better. Available also as diodes, triodes and tetrodes.

The VXR-130 subminiature gaseous voltage regulator tubes provide a new production and laboratory tube innovation. It supplies very close regulation with extreme stability where regulation must be maintained over a long period of time. Operation is at 130 volts at an operating current range of 1.0 to 2.5 ma. Write for particulars.

Victoreen provides a complete range of instruments for measurement and protection in the field of nuclear physics including Geiger-Mueller counting systems and scaling circuits for the laboratory or portable instruments for field service. The experience of twenty years devoted exclusively to radiation instruments assures quality performance.

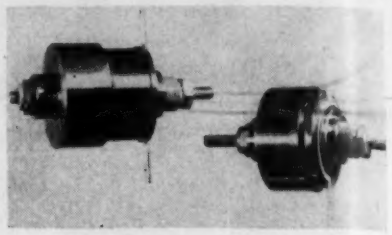


The VG series mica window Geiger-Mueller Counter is designed for exacting laboratory requirements.

Production is closely controlled for uniform and consistent tube characteristics. Highly regarded and recommended by research and laboratory engineers.

Offered in window thicknesses from 4.5 to 2.0 mgm. per sq. cm. Plateau length 200 volts, slope of plateau less than 5% per 100 volts.

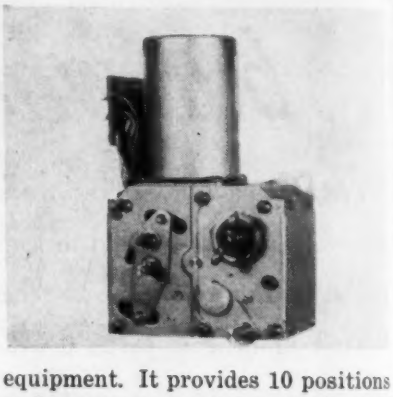
THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVENUE
CLEVELAND 1, OHIO



1 between maximum and minimum capacitance has a maximum outside diameter of $\frac{7}{8}$ inch and an overall length of $1\frac{3}{4}$ inches. Flash rating is 500 volts and capacitance is adjustable from 5 to 150 micromicrofarads. The curve is substantially linear with rotation.

Positioning Mechanism (22)

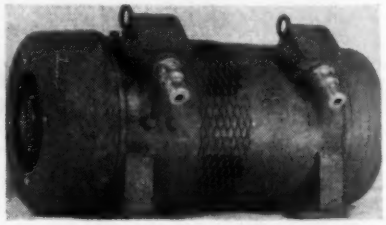
COLLINS RADIO CO., Cedar Rapids, Iowa. The type 496A Autotune is a repositioning mechanism primarily designed as a tuning control for home radio receivers and industrial



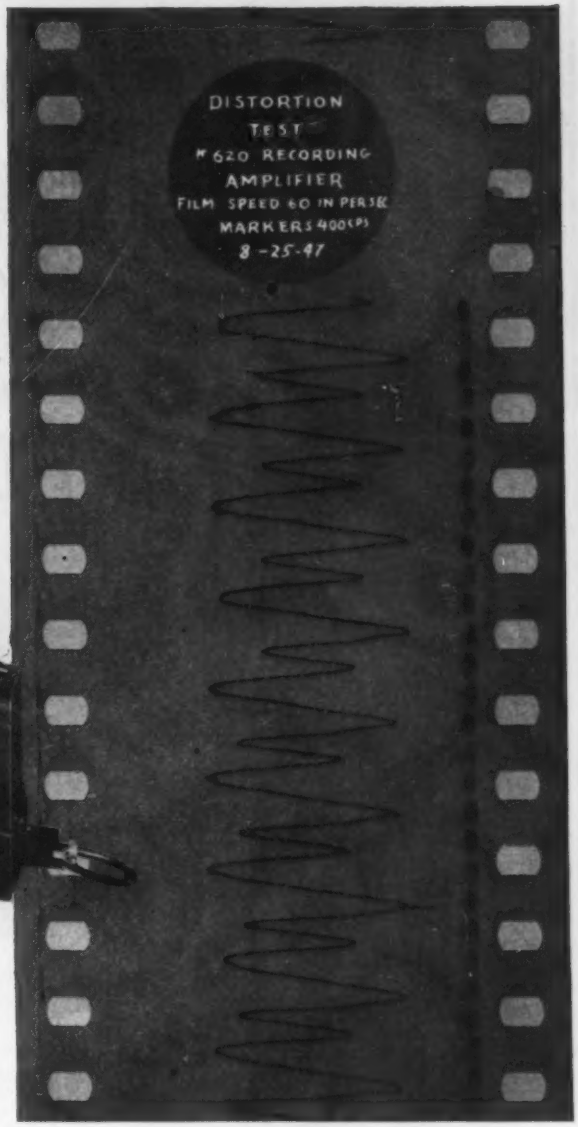
equipment. It provides 10 positions and reset accuracy is within 0.05 degree. Remote operation is by pushbutton or tap switch. Maximum operating time required is six seconds.

High Frequency Motor Generator (23)

KATO ENGINEERING CO., Mankato, Minn. A new 14-pole generator designed to run at 3,440 rpm produces 1,000 volt-amperes at 400 cycles. A 4-pole motor with four sets of



NEW!



35 mm Fairchild Oscillo-Record Camera

Once again, Fairchild has met a great need of the electronic laboratory—with the first general purpose, easy to use camera ever designed specifically for recording both single exposures or continuous recordings of cathode ray oscilloscope images.

Fairchild's new OSCILLO-RECORD CAMERA is so simple to set up and operate that anyone in the laboratory can make perfect photographic records of high-speed transients, stationary patterns of periodically recurring phenomena, or any other type of phenomena that can be put on a cathode ray oscilloscope.

Fairchild's new OSCILLO-RECORD CAMERA can be attached or removed from the oscilloscope instantly without tools. Special mounts make positioning automatic and leave all oscilloscope controls unobstructed. The camera is permanently in focus and can be loaded and operated in ordinary room light. The scope may be viewed during recording and hand written data may be recorded directly on the film for permanent record. And no special adapters or changes in camera equipment are required to shift from single exposures to continuous recordings.

Want more details? Address: 88-06 Van Wyck Boulevard, Jamaica 1, New York.

Records BOTH Still and Continuous Cathode Ray Oscilloscope Images

Specifications: The complete Fairchild assembly consists of a 35 mm roll film Camera, Electronic Film Speed Control Unit, Periscope Cone, Mount, Cables and Data Card Unit.

Film Speed: 1 inch per minute to 3,600 inches per minute.

Exposure Capacity: Single exposures up to double frame length. Continuous exposures up to 100 feet internal; 400 to 1,000 feet with external magazine.

Recording Time: With 100 foot reels—20 seconds to 20 hours; 1,000 foot reels—3⅓ minutes to 8⅓ days. Speed is recorded along edge of film.

Lens and Shutter: 50 mm f/2.8 lens in a Wollensak No. 2 shutter (f/1.5 lens optional) 1 to 1/400 second shutter speeds.

Data Record: A data card can be recorded at the beginning or end of each run.

Film Record: The cathode-ray beam writes a continuous record either back and forth across the film when the "X" axis is used; or diagonally across the film when the "Y" axis is used. The scope may be viewed while the camera is recording.

Fairchild CAMERA AND INSTRUMENT CORPORATION

MAKERS OF: AERIAL CAMERAS, MEDICAL X-RAY CAMERAS, POTENTIOMETERS, SOUND EQUIPMENT, SPECIAL MOTORS, ETC.

It's Better Because It's Bendix!

Now Available!

Aviation Standard

Bendix DYNAMOTORS

Bendix*—world famous for top-flight aviation quality—now makes available to the radio industry these low-cost D.C. Transformers.

- Specially designed for long life, light weight, and low ripple.
- Standard diameters run 2¾, 3⅜, 4, 4½, 5 and 5¼ inches.
- From 12 to 1100 volts and from 15 to 500 watts output.
- Continuous duty—enclosed.
- Intermittent duty—ventilated.
- Single, dual, and triple output.
- Regulated and unregulated.

Write to the address below for detailed information on these and other Bendix Dynamotors to meet your power requirements.

*REG. U.S. PAT. OFF.

STANDARD RATINGS

Model	Frame Size	Input Volts	Output Volts	Output Watts	Approx. Weight
DA58A	2¾"	14	250	15	2 lb. 12 oz.
DA1A	3⅜"	14	230	23	5 lb.
DA77A	4"	5.5	600	104	9 lb. 12 oz
DA1F	4½"	25	540	243	11 lb. 8 oz.
DA7A	5¼"	26.5	1050	420	26 lb. 10 oz.

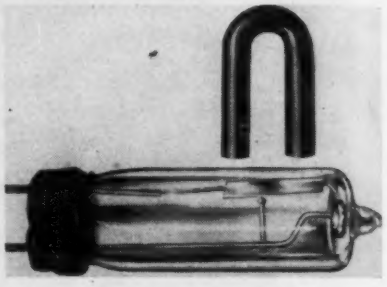
RED BANK DIVISION of Bendix AVIATION CORPORATION

Red Bank, New Jersey

brushes is provided. Approximately 7 percent regulation is possible with unity power factor. Net weight of the total equipment is 210 pounds.

Magnetic Mercury Switch (24)

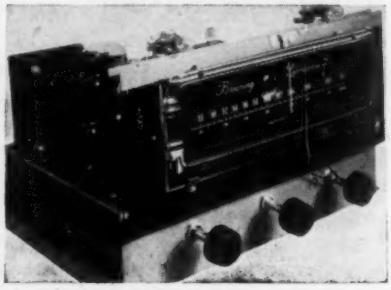
MINNEAPOLIS - HONEYWELL REGULATOR CO. A magnet attached to an actuating mechanism is used to



pull one switch electrode out of a mercury pool, thus breaking a circuit. The switch may also be operated in the reverse direction so as to close a circuit.

F-M Tuner (25)

BROWNING LABORATORIES, INC., 751 Main St., Winchester, Mass. Model RV-10 f-m tuner covers the range 88 to 108 megacycles. The Arm-



strong circuit using double limiters is employed to attain suitable reception with a 10-microvolt signal. Antenna input is designed for 300-ohm feeder and a tuning indicator is provided. Complete with power supply, the unit is also available with standard panel for rack mounting and is designated RV-11.

Heavy Duty Thyratron (26)

FEDERAL TELEPHONE AND RADIO CORP., Newark, N. J. A new 15,000 volt mercury vapor thyratron type

GLOBAR TEMPERATURE SENSITIVE RESISTORS

Where Temperature Changes Affect Performance

RESISTORS possessing negative temperature coefficients of electrical resistance are useful in electrical circuits involving wire coils. Changes in the temperature of the coils affect their resistance thus adding a variable to the overall performance of devices.

Aircraft instruments are an excellent example. Because aircraft, equipped with hundreds of instruments, operate at extreme and varying temperatures, it is important that instruments and important circuits are corrected for these changes in temperatures. This can be done by inserting resistors, having a negative coefficient of resistance, in the circuits. Here, they offset the positive coefficient of wire used in relay windings, field coils, and the moving elements of meters.

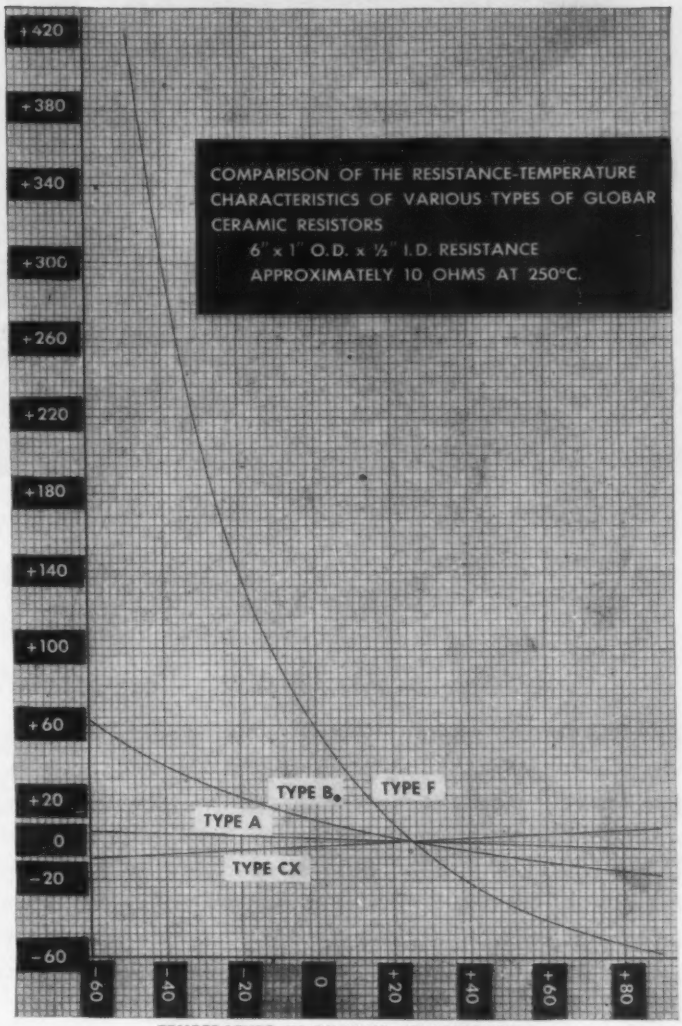
GLOBAR ceramic resistors offer a wide range of compensation as shown in this graph. The curves were plotted from performance data of resistors selected at random.

The degree of compensation obtainable is within the control of the circuit designer.

TYPICAL SUGGESTED USES ARE:

1. Temperature correction for voltmeters, ammeters, and other meters.
2. Compensation for increase in resistance of motor and generator field coils.
3. Compensation for increase in resistance of relay coils.
4. Direct measurement of low temperature up to 400°F.
5. Protection of the cathode heaters of vacuum tubes.
6. Protection of pilot lights in A.C. D.C. radio receivers.
7. Pilot flame protection.

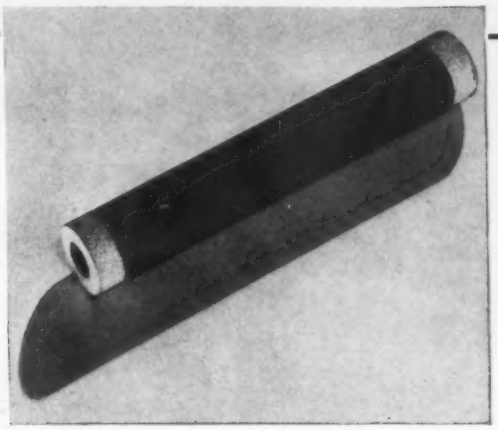
The Carborundum Company, Globar Division, Niagara Falls, New York.



GLOBAR Ceramic Resistors

BY CARBORUNDUM

TRADE MARK

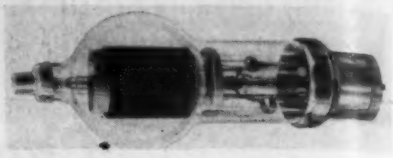


"Carborundum" and "Globar" are registered trademarks which indicate manufacture by The Carborundum Company

For
Superlative Reception!

Designed for use wherever high fidelity reception is required, the new postwar Meissner AM-FM Tuner and AM Tuner are now available for your most exacting requirements . . . Both of these new precision designed components cover the broadcast band from 527 to 1620 kcs. and the AM-FM Tuner also covers the FM band from 88 to 108 mcs. At 105-125 volts, 50-60 cycles, power consumption is 80 watts for the AM-FM Tuner and 60 watts for the AM Tuner. For further more complete information on these new quality units, write today to the address below;

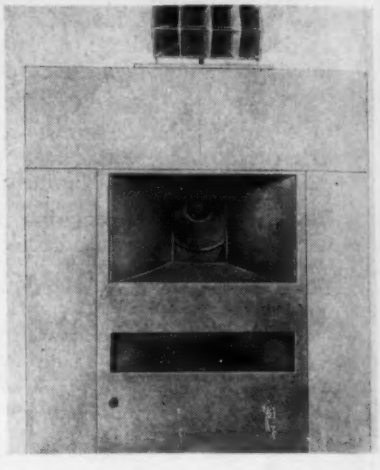
Meissner
ELECTRONIC DISTRIBUTOR AND
INDUSTRIAL SALES DEPARTMENT
MAGUIRE INDUSTRIES, INC.
500 W. HURON STREET • CHICAGO 10, ILLINOIS
EXPORT ADDRESS: SCHEEL INTERNATIONAL
4237 N. LINCOLN AVE., CHICAGO 18, ILL. CABLE—HARSCHEEL



F-5563 has been designed for both communications and industrial use. Grid voltage in typical service would be minus 70 volts. Average anode current is 1.6 amperes and peak current 6.4 amperes.

Auditorium Speaker (27)

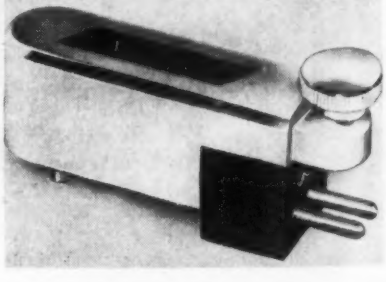
ALTEC LANSING CORP., 250 West 57th St., New York 19, N. Y. For small auditoriums and theaters seating up to 1,000, the new type



800 speaker gives a frequency response from 50 to 15,000 cycles. Two speaker units, one for low-frequencies and the other for high, are provided. Depth of the equipment is 23 inches.

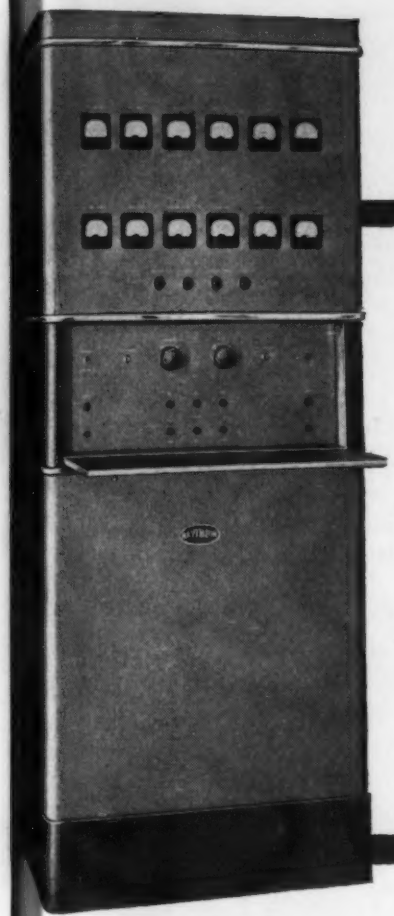
Pickup Adapter (28)

TECHNICAL PRODUCTS INTERNATIONAL, 453 West 47th St., New York 19, N. Y. The Vibromaster type M adapter makes it possible to use the G-E variable-reluctance



More and More 250 Watt Stations

are being powered by Raytheon

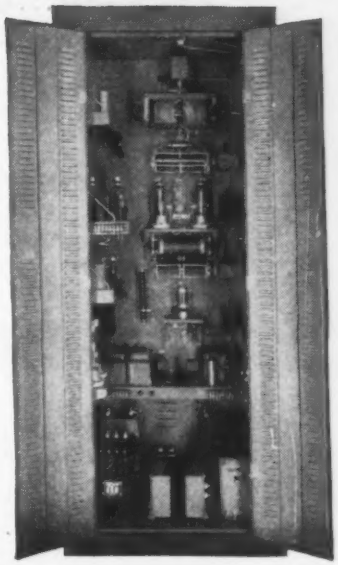


Here's the AM Transmitter that small-station owners are turning to... for its dependable, simpler circuits... its advanced design ...its modern, "dress-up" beauty!

HERE'S WHAT THE SMALL STATION NEEDS!

...Study these RAYTHEON features before you choose any transmitter, for replacement or new installation.

1. **Simplified, More Efficient Circuits**—A high level modulation system eliminates necessity of complicated and critical adjustment of linear amplifiers and minimizes harmonic distortion.
2. **Increased Operating Efficiency**—The use of the most modern improved components which are operated at well below their maximum capacity together with simplified circuit design greatly increases overall operating efficiency.
3. **Greater Dependability**—Due to the use of Triode type tubes, feedback failure will not cause a complete breakdown and the signal quality will still be good. Cooled by natural convective air currents, it is not subject to damage or fire caused by a blower failure.
4. **Simple, Speedy and Accurate Tuning**—All operational controls are centralized on the front panel; every circuit is completely metered and instantly checked. A clutch-equipped low-speed motor makes micrometer adjustment of the two tuned stages very easy.
5. **No Buffer Stage Tuning**—The use of a Video type amplifier in the buffer stage eliminates this complicated tuning.
6. **Silent Operation**—Natural air cooling means no blower noise, permits microphones in same room with transmitter.
7. **Low Audio Distortion**—Triode type tubes used in the audio stages have inherently lower distortion level. Specially designed audio transformers reduce audio distortion still further.
8. **Easy Servicing**—Vertical chassis, symmetrical mechanical layout and complete accessibility through double rear doors and hinged side panels make the RA-250 a favorite.
9. **Easily Meets All F.C.C. Requirements**—All electrical characteristics are well within the F.C.C. requirements. Noise level is −60 db below 100% modulation. Frequency response ±1 db from 30 to 10,000 cycles per second.



NOUNCED only a few short months ago, Raytheon 250 Watt AM transmitter has rdly won its way into the forefront of ll station broadcasting. Presented as a nsmitter of unsurpassed ign, unsurpassed styling unsurpassed engineering cellence, it has proved its ims on all three points. itors exclaim over its striking, modern beauty . . . beauty that gives a "show-place" air to any station. Station owners are delighted with its dependable performance . . . its silent operation . . . and the high fidelity signal it puts on the air.

Before you select a 250 Watt transmitter, be sure you possess *all* the facts. Write or wire for our specification bulletin.

RAYTHEON

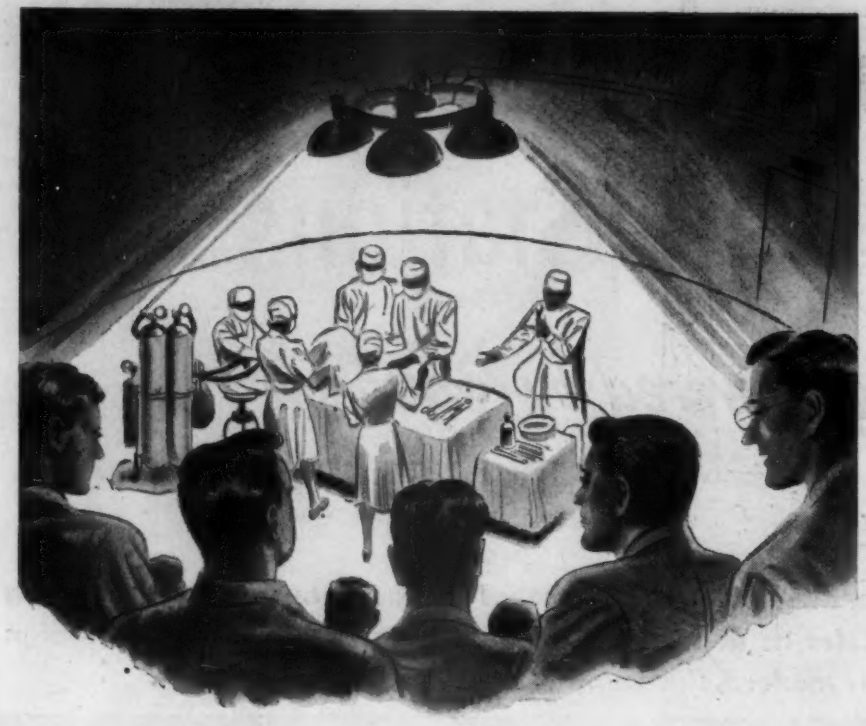
Excellence in Electronics

AYTHEON MANUFACTURING COMPANY, Commercial Products Division, Waltham 54, Mass.

Industrial and Commercial Electronic Equipment, Broadcast Equipment, Tubes and Accessories

Sales offices: Boston, Chattanooga, Chicago, Dallas, Los Angeles, New York, Seattle

VOTED TO RESEARCH AND MANUFACTURE FOR THE BROADCASTING INDUSTRY



Your magnetic recorder can help fight death

● By training young doctors in step-by-step surgery, the magnetic recorder you design can be a teaching weapon that helps fight pain and death. There are endless fields in teaching alone that magnetic recording will revolutionize. Start this vast new industry off right—look into Brush Magnetic recording components today:

Brush Paper Tape

- Easy to handle
- Extreme low-cost
- Can be edited . . . spliced
- Greater dynamic range
- Minimum wear on heads
- Excellent high frequency reproduction at slow speed
- Permanent . . . excellent reproduction for several thousand play-backs
- Easily erased

Brush Paper Tape will be furnished you either in bulk in varying widths or 1225 ft. ¼-inch wide on a metal reel (standard item).

These latest developments in magnetic recording equipment can now be obtained for radio combinations and other uses. Brush engineers are ready to assist you in your particular use of magnetic recording components.

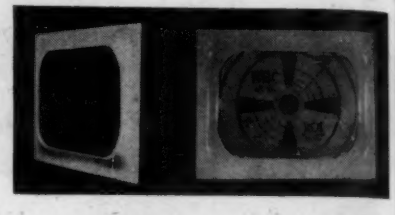
The Brush Development Co.

3405 Perkins Ave. Cleveland 14, Ohio

pickup or the Pickering 120M cartridges in the Western Electric 5A arm. A slight wiring change is necessary between arm and preamplifier, but the cartridge lugs need no soldering.

Mask and Protector (29)

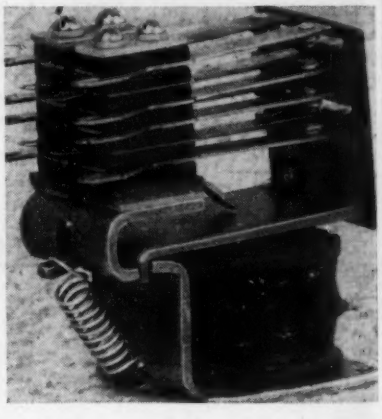
TELECTRO COMPONENTS, 141 Belleville Ave., 9, N. J. In sizes for all standard picture tubes, there is now available a combination picture



tube mask and protective plate made of optical plastic. Shadowed corners are eliminated and the entire picture tube surface can be viewed. Back view is shown at the left, and front at the right.

Vending Machine Relay (30)

GENERAL ELECTRIC CO., Schenectady 5, N. Y. A new multicontact a-c relay designed specifically for appliances and vending machines is



available in ratings of 5 amperes, 115 volts, and 5 amperes, 24 volts. Additional information is given in bulletin GEA 4864.

Voltage Regulator (31)

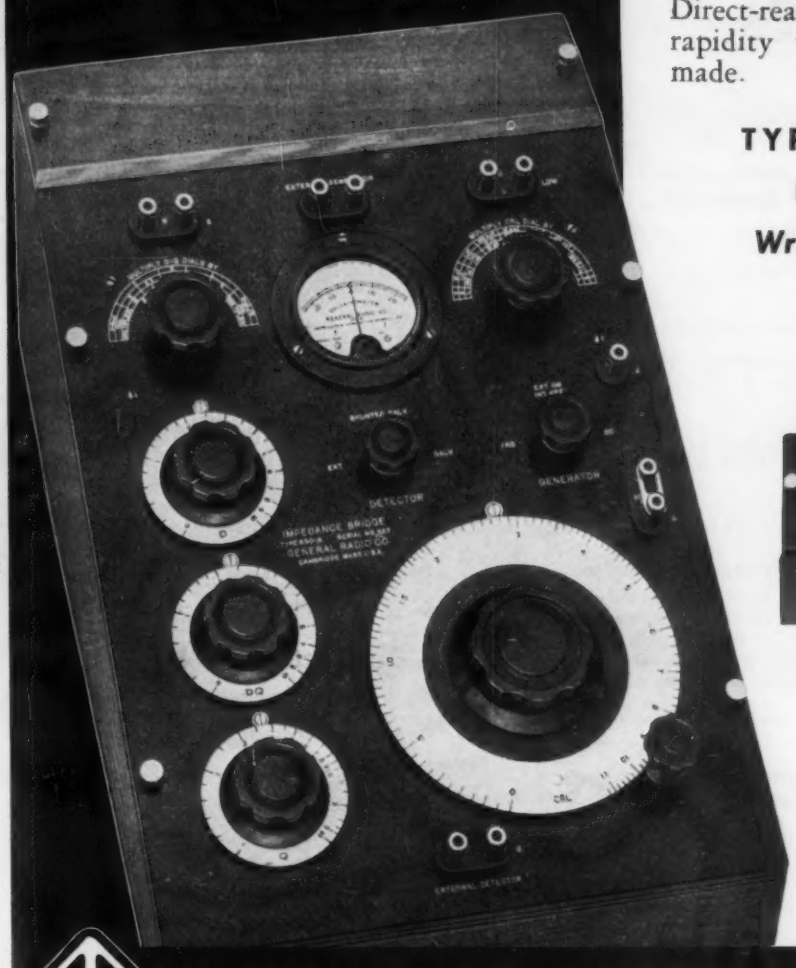
SORENSEN AND CO., INC., Stamford, Conn. Model E-3006 voltage regulator provides 6 volts and 0 to 300

TO MEASURE

- RESISTANCE
- INDUCTANCE
- CAPACITANCE
- STORAGE FACTOR
- DISSIPATION FACTOR

IN

ANY LABORATORY



In any laboratory where electrical equipment is used this self-contained, portable, direct-reading bridge is indispensable. It is always set up and ready for immediate use. Its accuracy is sufficient for the majority of routine measurements over these very wide ranges:

RESISTANCE: 1 milliohm to 1 megohm

INDUCTANCE: 1 microhenry to 100 henrys

CAPACITANCE: 1 micromicrofarad to 100 microfarads

STORAGE FACTOR (X/R): .02 to 1000

DISSIPATION FACTOR (R/X): .002 to 1

The bridge includes built-in standards, batteries, a 1000-cycle tone source for a-c measurements, a zero-center galvanometer d-c null detector and terminals for a headset for 1000-cycle null detection. Provision is made for use of an external generator for measurements over a wide range from a few cycles to 10 kilocycles. Direct-reading dials add greatly to the ease and rapidity with which measurements can be made.

TYPE 650-A IMPEDANCE BRIDGE.....$240.00

Write for complete information

This useful accessory converts the Type 650-A bridge to a-c operation. It includes a vacuum-tube oscillator, amplifier, and rectifier for providing dc for the bridge. All are mounted in a metal cabinet with top control panel which replaces the wooden cover used on the battery compartment. The sensitivity of the bridge is increased greatly with this oscillator-amplifier for both a-c and d-c measurements. TYPE 650-P1 OSCILLATOR-AMPLIFIER — $150.00.

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 | 920 S. Michigan Ave., Chicago 5 | 950 N. Highland Ave., Los Angeles 38

Don't lose your head over shortages!

When you need supplies and replacement parts *fast*, specify Air Express—and forget your worries. Your shipment arrives in *hours*, not days. Air Express brings your most distant suppliers close at hand. Even coast-to-coast overnight shipments are now routine.

Because Air Express goes on every flight of all Scheduled Airlines, your shipments never "grow moss"—never have to wait around for loads to accumulate. Rates are low, and you're getting better service than ever because of faster planes and increased schedules. For better, *more profitable* customer service, use Air Express regularly.

Specify Air Express-it's Good Business

- Low rates—special pick-up and delivery in principal U.S. towns and cities at no extra cost. • Moves on all flights of all Scheduled Airlines.
- Air-rail between 22,000 off-airline offices.
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Just phone your local Air Express Division, Railway Express Agency, for fast shipping action . . . Write today for Schedule of Domestic and International Rates. Address Air Express, 230 Park Ave., New York 17. Or ask for it at any Airline or Railway Express Office. Air Express Division, Railway Express Agency, representing the Scheduled Airlines of the United States.

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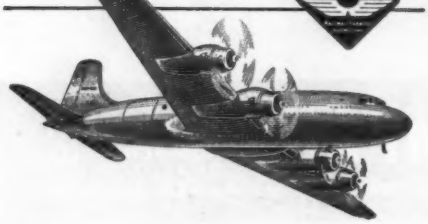
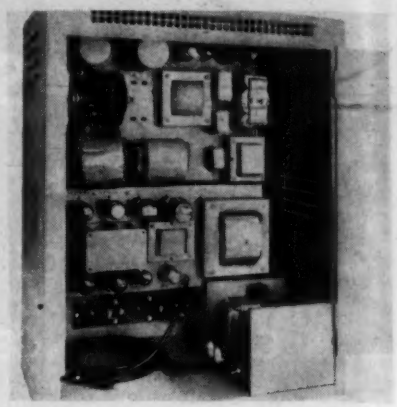
GETS THERE FIRST



Fastest delivery—at low rates

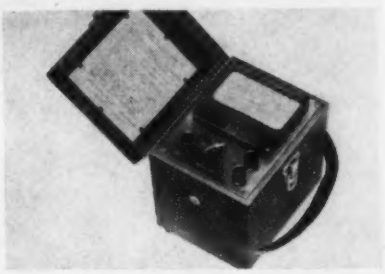
Refrigerator parts (**120** lbs.) in Detroit were needed in West Palm Beach *fast*. Picked up 4:20 PM the 16th, delivered 10 AM on 17th. **1135** miles, Air Express charge only **$40.52**. Other rates, any distance, similarly inexpensive and *fast*.



volts d-c output with input voltage over the range 95 to 125 volts (regulation for the high voltage is even better). • The low-voltage supply furnishes up to 15 amperes and the high voltage up to 100 milliamperes. Input frequency can vary between 50 and 60 cycles. The unit has been built with testing of instruments in mind.

Ohmmeter (32)

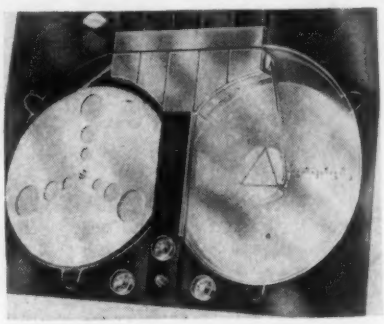
ASSOCIATED RESEARCH, INC., 231 South Green St., Chicago 7, Ill. A new precision ohmmeter measures from 1 to 100,000 ohms in four



overlapping ranges. Two No. 6 dry cells are used to operate the instrument. The model 246 ohmmeter is fully described in Bulletin 350.

Magnetic Tape Recorder (33)

SOUND RECORDER AND REPRODUCER CORP., 5501 Wayne Ave., Philadel-



ADJUSTABLE
MAGNETIC DAMPING

As applied by Esterline-Angus Company, Inc., of Indianapolis, Indiana, on a Model A. W. Electrodynamometer Instrument Movement

A Typical Application of Thomas & Skinner Permanent Magnets

Fig. 1—The magnets employed in this particular damping application are provided in Alnico II—which is cast with mounting holes cored. The necessity to adjust the damping posed an unusual problem in magnet engineering and fabrication—and in quality control. Note the small nub on the magnet which serves as a pointer in the installation.

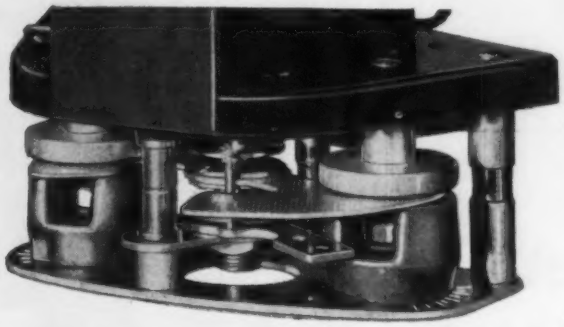
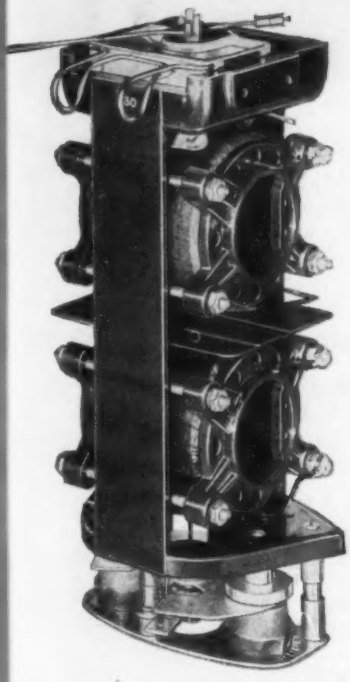
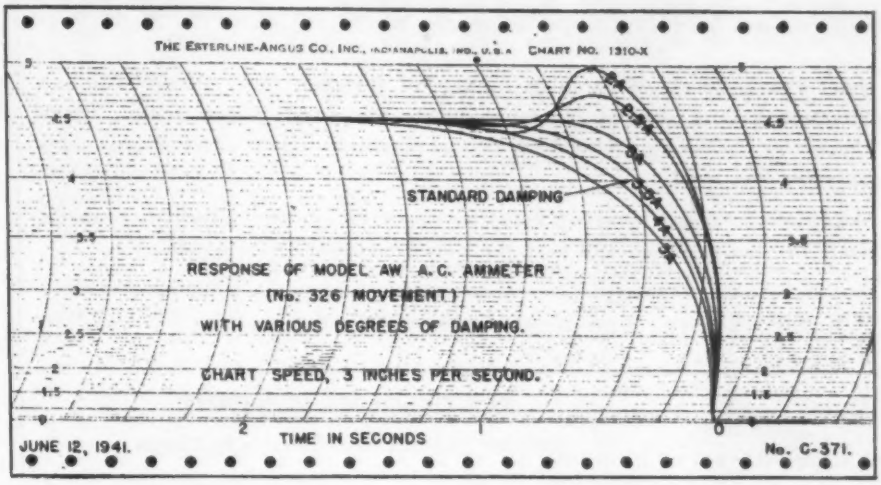


Fig. 2—Each magnet is installed so that it may be rotated on its own axis. Rotation of the magnet changes the position of the poles with respect to the moving vane passing through the magnetic field and by this method, damping is adjusted for optimum operation. The photo at lower left shows the complete measuring element of the instrument.

Fig. 3—The range of damping which these magnets make possible is shown by the chart on which response curves were plotted through a three-second period for each magnet position as indicated by a calibration on the magnet adjustment scale shown in Fig. 2.




THE ESTERLINE-ANGUS CO., INC., INDIANAPOLIS, IND., U.S.A. CHART NO. 1310-X
STANDARD DAMPING
RESPONSE OF MODEL AW A.C. AMMETER
(No. 326 MOVEMENT)
WITH VARIOUS DEGREES OF DAMPING.
CHART SPEED, 3 INCHES PER SECOND.
TIME IN SECONDS
JUNE 12, 1941.
No. C-371.

● This is but one of many adjustable and constant magnetic damping problems solved by the wealth of technological and fabrication skill developed by Thomas & Skinner engineers and craftsmen through 46 years of permanent magnet design and production. Your inquiries on the application of permanent magnets to your products are solicited—and will be given prompt attention. Write for the latest technical bulletin on use, design and fabrication of permanent magnets.

THOMAS & SKINNER
STEEL PRODUCTS COMPANY

1122 E. 23RD STREET • INDIANAPOLIS, INDIANA

FLUX

Photo Courtesy Bell Aircraft Corp.

Before you solder *be sure of your FLUX*

Don't risk solder bond breakage because of incorrect flux! Every soldering operation has its own specific requirements for a tight, clean bond. That's why Kester has developed hundreds of flux formulas to meet exact specifications for every flux need.

Salts paste, or liquid—you can count on Kester Fluxes in any form to properly clean, prevent oxidation and pave the way for reliable solder bonds.

Half a century of practical experience stands behind the Flux specifications of Kester engineers. Consult them without obligation on any flux problem.

KESTER SOLDER COMPANY

4204 Wrightwood Ave., Chicago 39, Illinois

Eastern Plant: Newark, N. J. **Canadian Plant: Brantford, Ontario**

KESTER
Solder Fluxes
STANDARD FOR INDUSTRY

phia, Pa. The Magnesonic recorder-reproducer uses magnetic tape furnished on reels that accommodate up to an hour's program. The apparatus has sufficiently great audio range to allow recording of music and is designed primarily for home use.

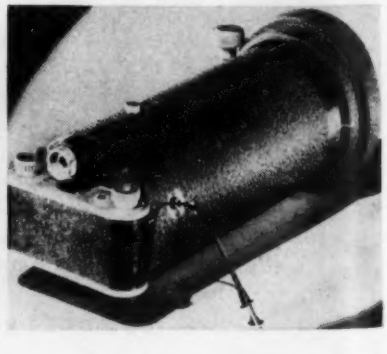
Industrial Switch (34)

MICRO SWITCH, Freeport, Ill. Type N2 die-cast enclosed switch is designed particularly for cam and slide actuation in industrial applications. A synthetic rubber boot

covers the operating plunger and a gasket seals the switch unit when it is mounted on rigid conduit, making the switch impervious to moisture and dirt.

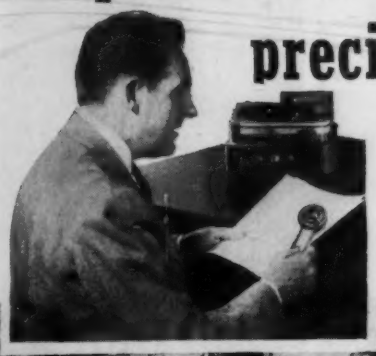
Scopic Camera (35)

ALLEN B. DUMONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J. Type 271-A oscillograph camera uses 35-mm film and is arranged with a fixed-focus hood, the far end

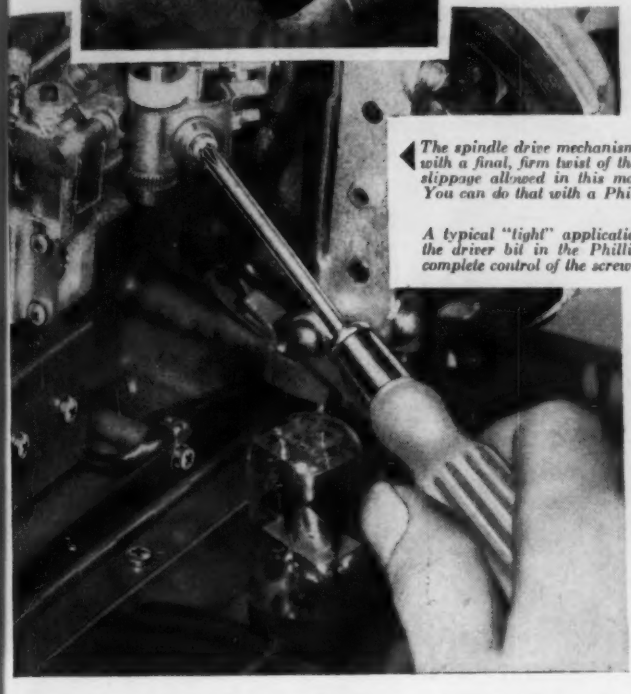


"Indispensable to the exacting assembly of precision electronic instruments!"

say the makers of the Gray AUDOGRAPH

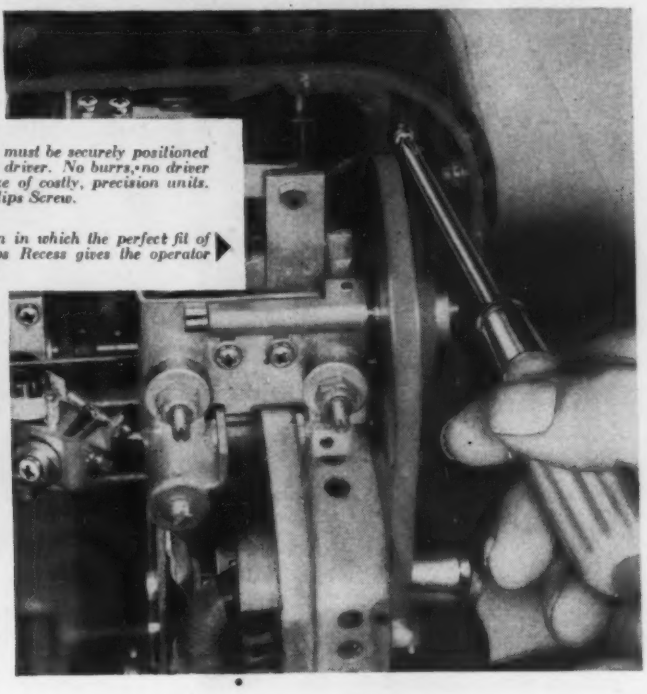


High spots from an independent survey . . . part of a continuing study by James O. Peck Co., of assembly savings made with Phillips Screws in leading plants.



The spindle drive mechanism must be securely positioned with a final, firm twist of the driver. No burrs, no driver slippage allowed in this maze of costly, precision units. You can do that with a Phillips Screw.

A typical "tight" application in which the perfect fit of the driver bit in the Phillips Recess gives the operator complete control of the screw.



"OUR MAJOR PROBLEM on the Audograph, an advanced electronic soundwriting machine," explained Gray's chief engineer, "is assembling small precision components without disturbing fine tolerance or damaging highly finished surfaces. Phillips Screws are the surest solution of that problem.

"PRECISE ASSEMBLY EASIER WITH PHILLIPS. The perfect fit of the driver in the recessed head speeds finding the thread. Operators easily position each component precisely. Driving in constricted places and at angles is far easier with Phillips Screws.

"AVOID DRIVER SLIPPAGE. 'Skids' would be very costly where so many precision units and expensively finished parts are compactly assembled. The cost of such damage would be out of all proportion to the cost of the parts . . . when interruption of our production due to disassembly and reassembly is figured in. At several points even a slight burr on a screw head could disturb the precision of a vital part. Phillips Screws remove the possibility of such damage.

"PHILLIPS HEAD IS PART OF SMOOTH STREAMLINING. The neat, modern appearance of the recessed head complements the ultra modern design of the Audograph."

YOU'LL FIND ANSWERS TO QUESTIONS about your own assembly costs in the complete report of the Audograph assembly . . . and in other reports, covering wood, metal and plastic products . . . FREE on request. Mail the coupon TODAY!

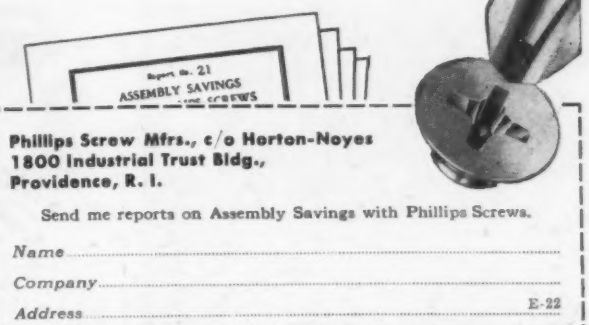
PHILLIPS *Recessed Head* SCREWS

Wood Screws • Machine Screws • Self-tapping Screws • Stove Bolts

American Screw Co.
Central Screw Co.
Continental Screw Co.
Corbin Screw Div. of American Hdwe. Corp.
Elco Tool & Screw Corp.
The H. M. Harper Co.
International Screw Co.
Lamson & Sessions Co.
Milford Rivet and Machine Co.
National Lock Co.

24 SOURCES

National Screw & Mfg. Co.
New England Screw Co.
Parker-Kalon Corporation
Pawtucket Screw Co.
Pheoll Manufacturing Co.
Reading Screw Co.
Russell Burdsall & Ward Bolt & Nut Co.
Scovill Manufacturing Co.
Shakeproof Inc.
The Southington Hardware Mfg. Co.
The Steel Company of Canada, Ltd.
Sterling Bolt Co.
Stronghold Screw Products, Inc.
Wolverine Bolt Company



Phillips Screw Mfrs., c/o Horton-Noyes
1800 Industrial Trust Bldg.,
Providence, R. I.

Send me reports on Assembly Savings with Phillips Screws.

Name .....

Company .....

Address E-22

Designed for

Application

90810 HIGH FREQUENCY TRANSMITTER

The No. 90810 crystal control transmitter provides 75 watt outout (higher output may be obtained by the use of forced cooling) on the 10–11, 6 and 2 meter amateur bands. Provisions are made for quick band shift by means of the new 48000 series high frequency plug-in coils.

Crystal and circuit development on "third overtone frequency output crystals" has made possible this highly efficient unit, providing high output and crystal control with a minimum of tubes.

The No. 90810 consists of a Bliley CCO-2A crystal oscillator unit, using a 6AG7 crystal oscillator, a 2E26 tripler and an 829B power amplifier stage. For 10 meter operation, a conventional crystal is used, the crystal unit driving the 829 direct. For 6 meter operation, an overtone crystal is used in the crystal stage and drives the 829 directly as a power amplifier. For 2 meter operation, the overtone crystal is likewise used, but the output from the crystal unit is fed through the 2E26 tripler.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY

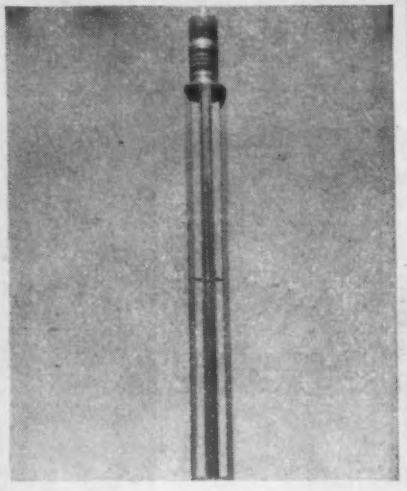
MALDEN

MASSACHUSETTS

of which clamps to the usual supporting ring of a 5-inch oscilloscope. All controls have been simplified and the camera is adjustable in every possible way in order to photograph waveforms appearing on the screen.

F-M Antenna (36)

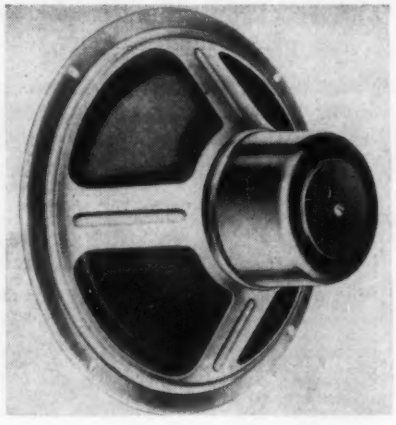
WORKSHOP ASSOCIATES INC., 66 Needham St., Newton Highlands 61, Mass. Type FMT-1 antenna is equal to or superior to a 3-bay half-wave spaced array for f-m broadcast transmitting on the high band.



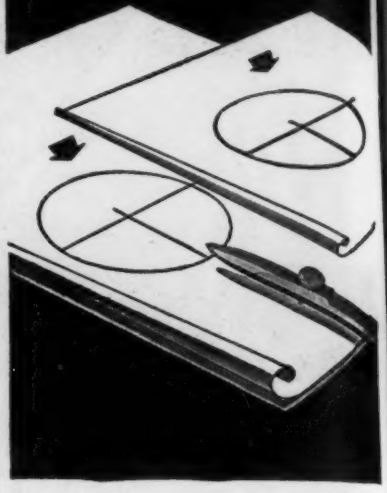
The radiation is horizontally polarized. Mechanically, the antenna consists of four aluminum alloy channels rigidly mounted to circular end castings. Provision is made for mounting a standard 300-mm beacon.

Loudspeakers (37)

PERMOFLUX CORP., 4900 West Grand Ave., Chicago. Ill. A new line of



Tracing cloth that defies time



● The renown of Imperial as the finest in Tracing Cloth goes back well over half a century. Draftsmen all over the world prefer it for the uniformity of its high transparency and ink-taking surface and the superb quality of its cloth foundation.

Imperial takes erasures readily, without damage. It gives sharp contrasting prints of even the finest lines. Drawings made on Imperial over fifty years ago are still as good as ever, neither brittle nor opaque.

If you like a duller surface, for clear, hard pencil lines, try Imperial Pencil Tracing Cloth. It is good for ink as well.

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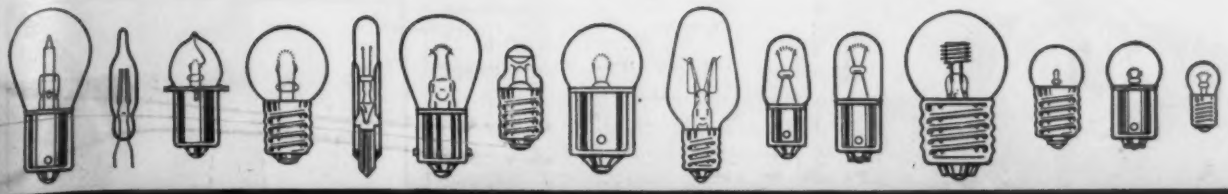
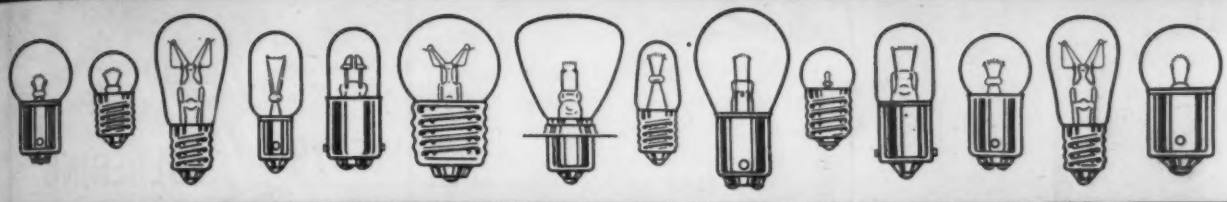
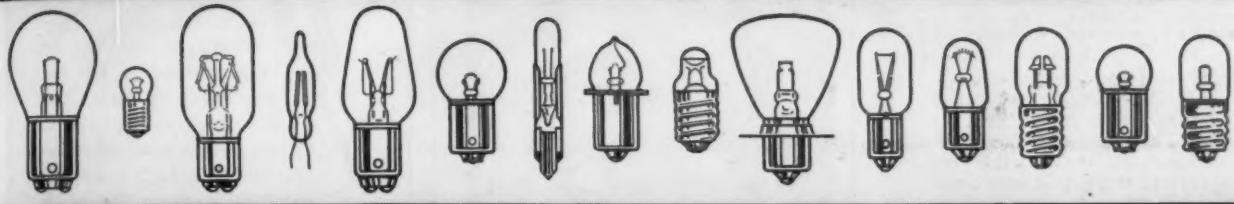
SOLD BY LEADING STATIONERY AND DRAWING MATERIAL DEALERS EVERYWHERE



These little bulbs can make



a big difference in the success



# of your product

Whatever miniature lamps you need...incandescent or neon-glow...GENERAL ELECTRIC makes 'em all!

What can these little bulbs do for your product?

This brief check list of typical uses may suggest an idea to you:

Illuminated dials
Decorative light effects
Safety lighting
Pilot lights
Lighted toys
Inspection lights
Lighted signals
Numeral indicators
Night lights
Pinball games

WHAT progressive manufacturer doesn't ask himself almost daily—"How can I make my products more useful, more saleable, more profitable?" Many designers answer that problem by using inexpensive miniature G-E light bulbs to add safety, convenience and beauty to a wide variety of products.

Whatever job you may have for miniature bulbs, there is a G-E lamp that will suit your purpose exactly. General Electric's line is complete—all sizes and types—all wattages and voltages — filament and neon-glow lamps—for delicate service or heavy duty. And the high quality of every bulb is backed by G-E Lamp Research.

To make sure you get the right lamp for your application, entrust the selection to specialists who know all kinds of miniature lamps intimately. G-E Lamp engineers have the experience and practical knowledge to assist you. Call your nearby G-E Lamp office for full information. Ask for your copy of "Big Jobs for Small Bulbs".

General Electric Co., Lamp Dept., Nela Park, Cleveland 12, Ohio.

G-E LAMPS

GENERAL ELECTRIC

NEW UNDERWRITER'S APPROVED
125 VOLT—CANDELABRA
BAYONET SOCKET ASSEMBLIES

NOW you can get fine *Underwriter's Approved* candelabra Dial Light Socket Assemblies by DRAKE! The No. 900 series is designed for radio use, and the No. A900 series for general use. Both are double contact, candelabra, bayonet Assemblies housing 115V household type lamps, available from 5 to 25 watts. They are U.L. approved for 75W-125V service. Can also be used with 6V automotive lamps.

The bayonet type eliminates vibration-loosened lamps and requires less space than screw type. Can be supplied with any type mounting bracket. Lead-in wires from 2½" to 60". Made to traditional DRAKE standards of precision and rugged dependability. Check with our engineers on your requirements, *today!*

ASK FOR OUR NEW CATALOG • NO OBLIGATION!

DRAKE

Socket and Jewel LIGHT ASSEMBLIES

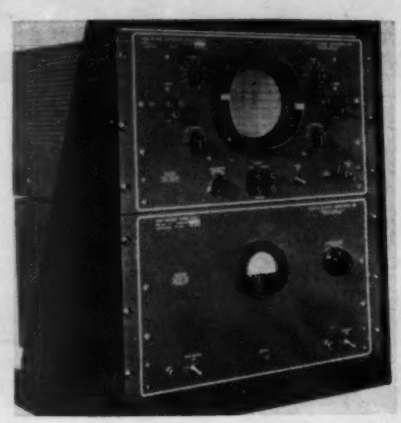
DRAKE
MANUFACTURING CO.
1713 W. HUBBARD ST., CHICAGO 22

NEW PRODUCTS (continued)

loudspeakers in sizes from 10 to 15 inches, using either permanent magnets or electromagnets, will reproduce sound from 30 to 12,000 cycles. Elliptical speakers and public address types with corrosion-resistant finish are also available.

High-Voltage Oscilloscope (38)

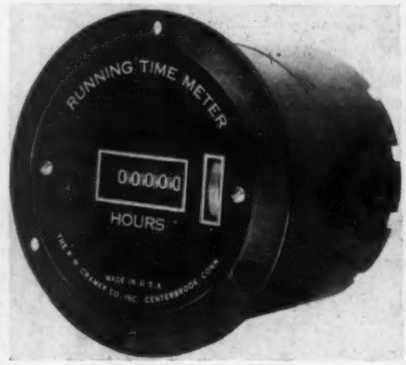
ALLEN B. DUMONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J. Type 281 cathode-ray indicator and type 286 high-voltage power supply employ a type 5RP-A tube with overall accelerating potential of 29



kilovolts. Under these conditions writing rates as high as 400 inches a microsecond can be recorded. Magnetic shielding is complete so that the instrument can be successfully used near power buses, and voltage regulation employed allows operation on factory power lines.

Totalizer (39)

R. W. CRAMER CO., INC., Centerbrook, Conn. Type E7 running time meter illustrated indicates in tenths up to 10,000 hours and then repeats. It can also be reset from



ELECTRIC SOLDERING IRONS

that are sturdily built for the hard service of industrial usage. Have plug type tips and are constructed on the unit system, with each vital part, such as heating element, easily removable and replaceable. In 5 sizes, and from 50 watts to 550 watts.

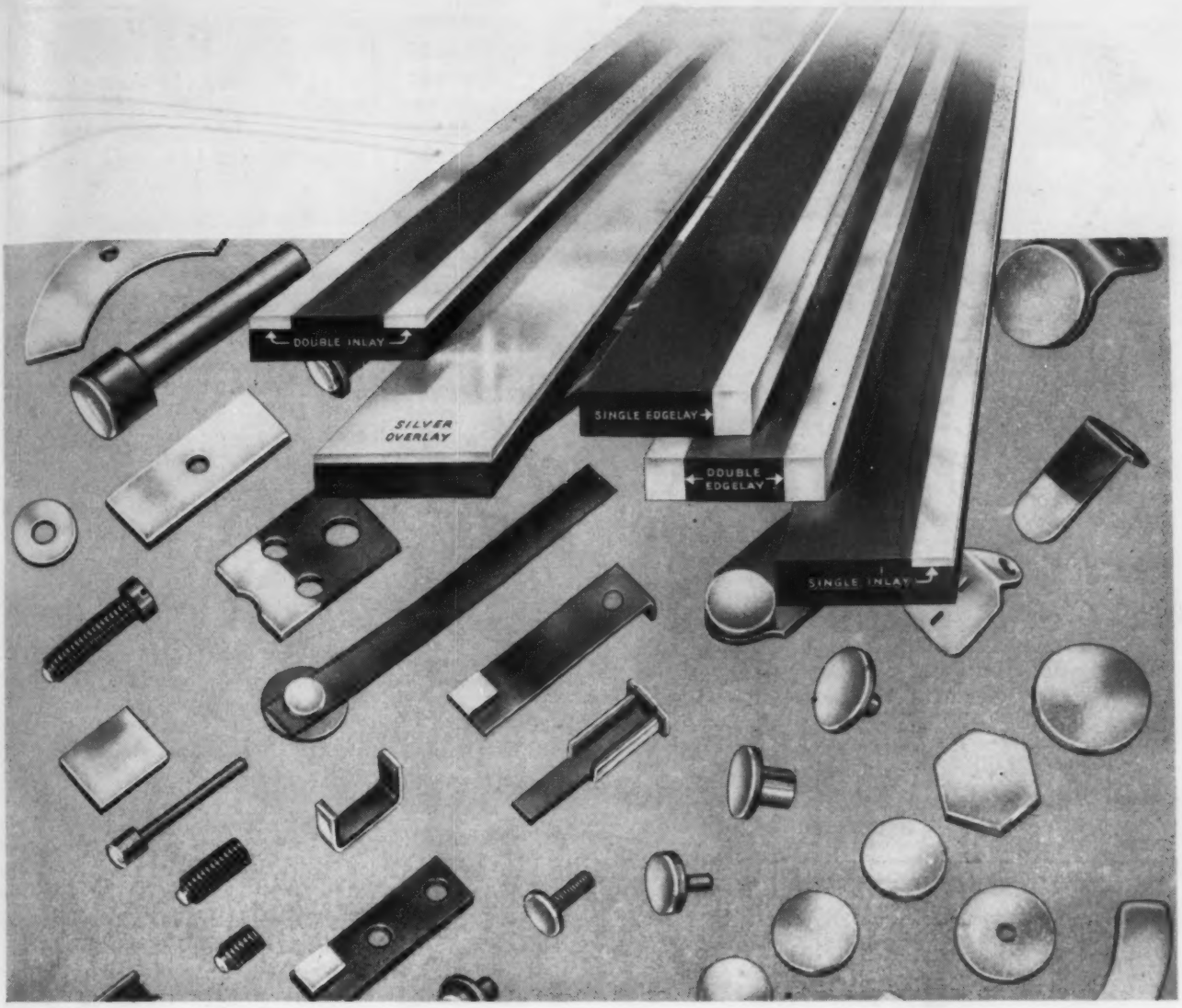
American Beauty

TEMPERATURE REGULATING STAND

This is a thermostatically controlled device for the regulation of the temperature of an electric soldering iron. When placed on and connected to this stand, iron may be maintained at working temperature, or through an adjustment on bottom of stand, at low or warm temperature.

For further information, write 115-1

AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICHIGAN
established 1894



YOU GET SOLID SILVER CONDUCTIVITY PLUS ECONOMY WITH GENERAL PLATE LAMINATED SILVER METALS AND CONTACTS

The big advantage of General Plate Laminated Silver metals and contacts is that they give you solid silver performance at a fraction of the cost of solid silver. Why — because General Plate permanently bonds a thin layer of silver to suitable inexpensive base metal, thus providing a contact face of high electrical conductivity at the point of actual contact.

General Plate Laminated silver metals, for your own fabrication, are available with silver bonded to base metal in the following stock . . . overlay, single or double inlay and single or double edgelay. General Plate contacts and fabricated parts are made to customers specifications. Laminated contact buttons, rivets and screw type contacts are also available. Advantages include — long contact life, greater strength, easier fabrication, and easier soldering, brazing or spot welding.

Write, specifying your problems.

GENERAL PLATE DIVISION

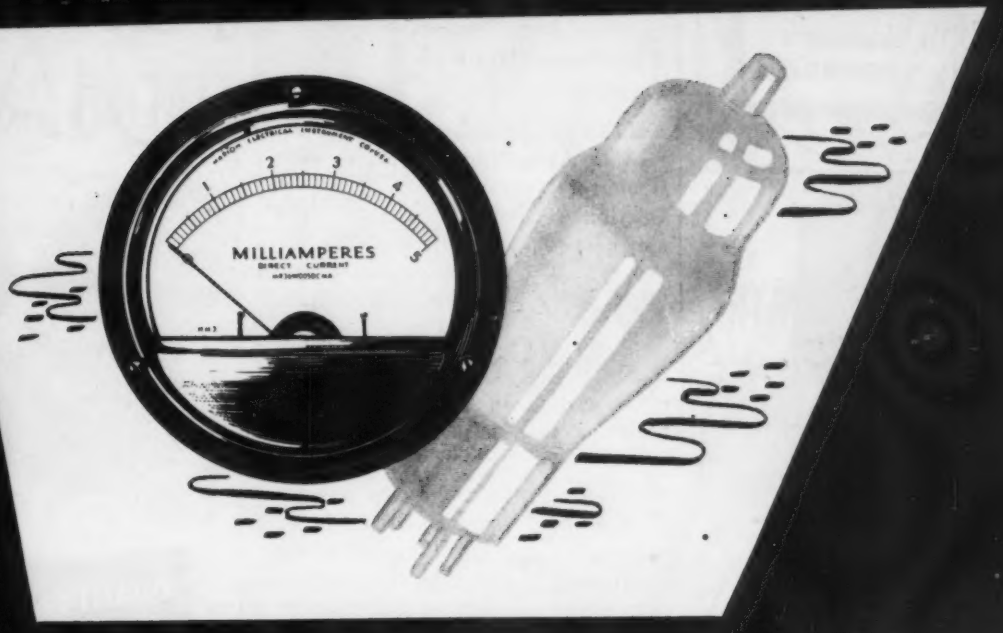
of Metals & Controls Corporation

ATTLEBORO, MASSACHUSETTS

VISIT OUR EXHIBIT — METAL SHOW CHICAGO Oct. 18-24 — BOOTH No. 1817

50 Church St., New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 2635 Page Drive Altadena, Calif.

In Step with Electronic Progress . . .
Modern Hermetically Sealed Instruments



SEALED LIKE A VACUUM TUBE

100% GUARANTEED!

Progressive manufacturers of electronic equipment declare an hermetic seal is as important in a meter as it is in any other product component. That's because meters are just as susceptible to the harmful effects of dust, moisture, corrosive fumes and other destructive factors as resistors, capacitors or transformers. Therefore, hermetically sealed meters are a "must" in achieving top product performance.

MARION HERMETICS ARE NOT PREMIUM PRICED

Marion glass-to-metal hermetically sealed meters offer you the accuracy, superiority and extended life of an hermetically *sealed* component at a price no higher than most competitive *unsealed* instruments. All Marion hermetically sealed instruments are 100% GUARANTEED.

LOOK AT THE FEATURES OF MARION "HERMETICS"

DURABLE

. . . Unaffected by extremes of heat or cold . . . permanently protected against dust, dirt, moisture . . . instrument malfunctioning minimized.

SHIELDED

. . . Heavy steel case gives magnetic and electrostatic shielding so important in modern high frequency equipment.

INTER-CHANGEABLE

. . . The Marion case, with its high conductivity plating, eliminates the need for separate shielding and permits interchangeability on any type panel without affecting calibration.

MARION "4 for 1" FEATURE

Interchangeable Round and Square Colored Flanges . . . one instrument can thus fill four different needs:

1. Round
2. Round for Steel Panel
3. Rectangular
4. Rectangular for Steel Panel

WRITE FOR FURTHER INFORMATION.

THE NAME "MARION" MEANS THE "MOST" IN METERS

MARION ELECTRICAL INSTRUMENT COMPANY

Manchester, New Hampshire

Small in size—
but big in Quality!

Western Electric
755A 8" LOUDSPEAKER

The smallest of a complete line of Western Electric speakers from 8 to 120 watts, the 755A offers quality reproduction that would make a giant proud.

Details? Here are just a few—8 watts power capacity . . . 70 to 13,000 cycle frequency response . . . 70° coverage angle . . . 4¾ lbs. weight . . . 2 cu. ft. enclosure needed . . . 4 ohms input impedance.

More details? Write Graybar Electric Company, 420 Lexington Avenue, New York 17, New York—or

ASK YOUR LOCAL **GraybaR**
BROADCAST REPRESENTATIVE

New Line **KENYON**

ISOLATION TRANSFORMERS

TYPE	VA	WT (lbs.)	L	W	H	ML	MW	FIG	LIST PRICE
I-10	25	2½	3⅝	2 11/16	3¾	3⅛	2	A	8.30
I-14	100	7½	5 3/16	3⅝	4¾	4 11/16	2½	A	14.00
I-18	250	14	6⅛	5½	5	5⅝	4½	A	22.50
I-22	750	50	9¾	7 3/16	6 3/16	4¾	6 3/32	B	59.00

Isolation Transformers with electrostatic shields. (Ratio 1:1) 115 Volts, 50/60 Cycles. Supplied with cord, plug and receptacle.

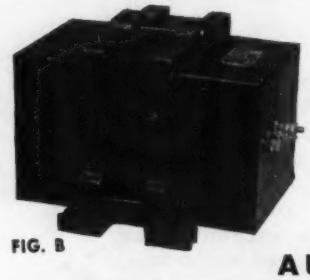


FIG. B

FIG. A

AUTO TRANSFORMERS

Auto Transformers 230/115 Volts, 50/60 Cycles.
Write for details today on KENYON's new line.

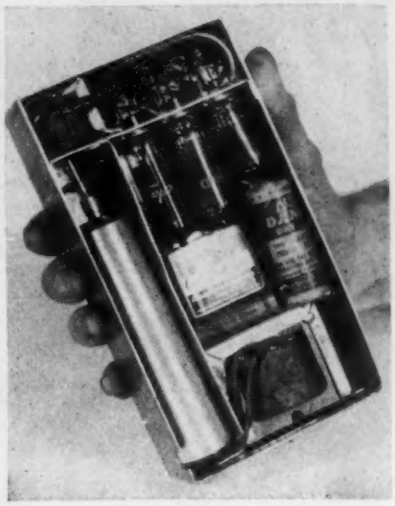
TYPE	VA	WT (lbs.)	L	W	H	ML	MW	FIG	LIST PRICE
I-40	50	2½	3⅝	2 11/16	3¾	3⅛	2	A	7.95
I-44	100	3½	4⅞	2 11/16	3¾	4⅜	2	A	9.55
I-48	250	8	5 3/16	3⅝	4¾	4 11/16	2½	A	14.90
I-52	500	14	6⅛	5½	5	5⅝	4½	A	22.00
I-56	1000	40	8½	7 3/16	6 3/16	3½	6 3/32	B	43.00

KENYON TRANSFORMER CO., Inc.
840 BARRY STREET NEW YORK, U. S. A.

the front. Available for 110 or 220 volts, the meters can also be furnished for 50 or 60 cycles. Type E5 is suitable for table use, while type E6 is enclosed in a metal housing for conduit connection.

Pocket Tester (40)

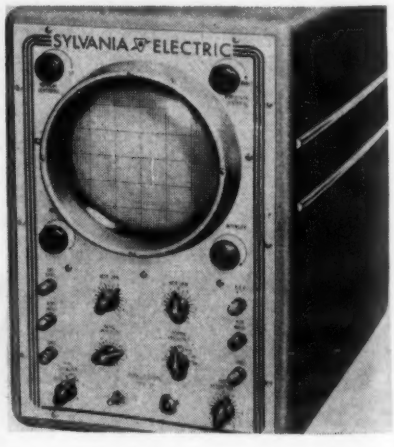
FEILER ENGINEERING CO., 422 S. Dearborn St., Chicago 5, Ill. Model TS-5 Pocket Stethoscope is a small signal tracer with its own speaker.



Any standard meter can be plugged in to convert the combination to an r-f vacuum tube voltmeter. An illustrated folder will be mailed on request.

Large Test Scope (41)

SYLVANIA ELECTRIC PRODUCTS INC., 500 Fifth Ave., New York 18, N. Y. A new 7-inch cathode-ray oscilloscope with higher-gain amplifiers than conventional test equipment weighs 37 pounds. The Z-axis in-



New ways Permanent Magnets

...are doing it better!

Pushing—pulling . . . gripping—twisting . . . lifting—holding . . . magically, the permanent magnet contributes the unfailing force of "packaged energy" to the function of countless commonplace things.

Actually millions of magnets serve us daily in communications, transportation, science, medicine, and industry . . . ranging in size from the tiny magnet in the hearing aid to the huge, heavy horn-shaped radar magnets.

"Packaged energy" may do some job or process better for you . . . or, within your product, may serve you more efficiently . . . more economically. Investigate its use. Our engineers will gladly work out the way in which this *independent source of power* is best suited to your needs.

MEASURING STICK
Attracts and *holds* small metallic particles floating in lubricating oil.

COFFEE MAKER
"Packaged Energy" *cuts off* current when coffee is ready.

OIL PLUG
Attracts and *traps* fine metal filings that settle through oil at the bottom of the automobile crankcase.

THERMOSTAT
"Packaged Energy" provides *snap action* for thermostats and safety controls.

TOOL HOLDER
Holds tools of all sizes, shapes . . . provides easy access.

Shown here are applications of permanent magnets utilizing *tractive* force. Other functions include:

1. Transformation of mechanical to electrical energy.
2. Transformation of electrical to mechanical energy.

PERMANENT MAGNETS MAY DO IT BETTER

Parker "51" Magnetix Pen Holder. Magnet secures holder to base . . . yet allows it to pivot freely. Eliminates friction or other fittings which fail or wear.

★ THE INDIANA STEEL PRODUCTS COMPANY ★

PRODUCERS OF "PACKAGED ENERGY"
6 NORTH MICHIGAN AVENUE * CHICAGO 2, ILL.
SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

PLANTS { VALPARAISO, INDIANA
CHAUNCEY, WESTCHESTER COUNTY, N. Y.

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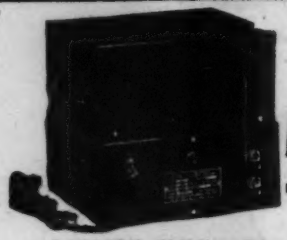
CURRENT CONVERSION
WITH
ATR QUALITY PRODUCTS



ATR "A"

BATTERY ELIMINATORS
For DEMONSTRATING and TESTING AUTO RADIOS
New Models . . . Designed for Testing D.C. Electrical Apparatus on Regular A.C. Lines. Equipped with Full-Wave Dry Disc Type Rectifier. Assuring Noiseless, Interference-Free Operation and Extreme Long Life and Reliability.
• Eliminates Storage Batteries and Battery Chargers.
• Operates the Equipment at Maximum Efficiency.
• Fully Automatic and Fool-Proof.
• Type 60-ELIA . . . Rated Output 6.3 Volts at 6.5 Amperes. Dealer Net Price $22.80
• Type 120C—ELIO . . . Rated Output 6.3 Volts at 14 Amperes. Dealer Net Price $37.20

ATR AUTO RADIO VIBRATORS
Designed for Use in Standard Vibrator-Operated Auto Radio Receivers. Built with Precision Construction for Longer Lasting Life. Prices are app. 15% lower.

ATR STANDARD AND HEAVY DUTY INVERTERS

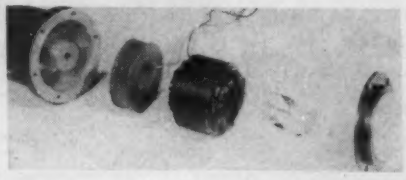
For Inverting D. C. to A. C.
Specially Designed for Operating A.C. Radios, Television Sets, Amplifiers, Address Systems, and Radio Test Equipment from D.C. Voltages in Vehicles, Ships, Trains, Planes and in D.C. Districts.
Write for New ATR Catalog—Today!

AMERICAN TELEVISION AND RADIO CO.
Quality Products Since 1931
SAINT PAUL 1, MINNESOTA — U.S.A.

put impedance to ground is approximately 0.5 megohm shunted by 30 micromicrofarads. Such a characteristic facilitates waveform study by means of intensity modulation.

Electromechanical Control (42)

KOLLSMAN INSTRUMENT DIV., 80-08 45th Ave., Elmhurst, N. Y. The Synchrotel serves as a virtually frictionless voltage control and synchronous transmitter. The de-



vice can be attached to the pointer of the most sensitive aircraft or other instrument without affecting accuracy. It converts the reading into electrical signals that can be sent to a remote station with high accuracy.

Television Capacitor (43)

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. Type RC-108 capacitor has a rating of 0.05 mi-

crofarad and 3,500 volts d-c working voltage. Housed in a metal cylinder, the unit is 1¾ inches in diameter and 3 inches long.

50-KW F-M (44)

RADIO CORP. OF AMERICA, Camden, N. J. Unique mechanical and electrical constructions have been used in the preproduction f-m transmitter amplifiers shown in order to insure safety to operating personnel and attain a power output of 50 kilowatts at 108 megacycles. The equipment employs a reactance-type modulator and frequency-correcting device, and is fully equipped for

precision-fabricated PLASTIC DIALS

QUALITY and SERVICE AT A PRICE THAT'S RIGHT

You can't go wrong when you depend on Sillcocks-Miller for plastic dials. These experienced engineers are recognized throughout the industry for their ability to fabricate plastic materials to close tolerances. The combination of this skill and complete production facilities provides a dependable source for the quality and service you want — at a price that's right.

Write for illustrated booklet or phone South Orange 2-6171 for quick action.

THE SILLCOCKS-MILLER CO.
10 West Parker Avenue, Maplewood, N. J.
Mailing Address: South Orange, N. J.

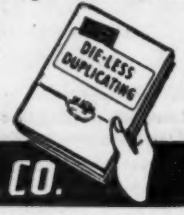
SPECIALISTS IN HIGH QUALITY, PRECISION-MADE PLASTICS FABRICATED FOR COMMERCIAL, TECHNICAL AND INDUSTRIAL REQUIREMENTS.

With Two DI-ACRO BENDERS

A difficult production problem of forming two bends in a long length of tubing was solved by "teaming up" two DI-ACRO Benders as illustrated. This dual-forming arrangement saved installation of special machinery. Two accurately formed bends are obtained in one operation —without distortion of the tube and at a cost competitive to power operated equipment. More than 300 pieces are completed per hour—600 individual bends.

"DIE-LESS DUPLICATING" Often Does it Quicker WITHOUT DIES

This is but one example of how DI-ACRO precision machines—Benders, Brakes and Shears—can accurately and economically duplicate a great variety of parts, pieces and shapes, without die expense.



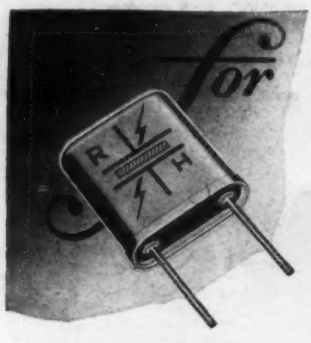
Write for Catalog—"DIE-LESS DUPLICATING"

◀DI-ACRO is pronounced "DIE-ACK-RO".

DI-ACRO PRECISION MACHINES DIE-LESS DUPLICATING

O'NEIL-IRWIN MFG. CO.

321 EIGHTH AVENUE • LAKE CITY, MINNESOTA



RH-7M

RADIO MANUFACTURERS . . . A LOW COST CRYSTAL

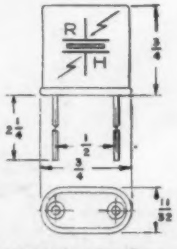
RH-7M is a new hermetically sealed crystal unit which combines wide frequency range and increased performance with low cost. RH-7M is provided with wire leads to specified length. On fixed frequencies of transmitters or receivers this unit can be soldered in directly with other components of the set thus eliminating plug in sockets and possibility of contact failure. RH-7M with prongs to fit standard sockets can be supplied on special order.

Any fundamental frequencies from 3 mc. to 20 mc. can be supplied with tolerances from 0.01% down to plus or minus 0.003% over a temperature range of minus 55° to plus 90°C.

For series resonance application frequencies of mechanical overtone (mode) from 15 mc. to 75 mc. can be supplied.

This unit is also very adaptable for low frequency filter circuits. CT cut, center mounted, plated crystals have a frequency range from 300 kc. to 600 kc. DT cut, center mounted crystals range from 200 kc. to 400 kc.

Patent Pending



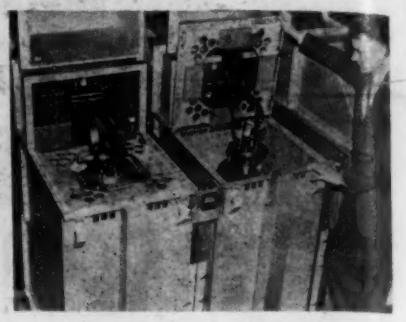
RH-7M Dimensions

R H

REEVES-HOFFMAN CORPORATION

SALES OFFICE: 215 EAST 91 STREET, NEW YORK 28, N. Y.

PLANT: 321 CHERRY STREET, CARLISLE, PA.

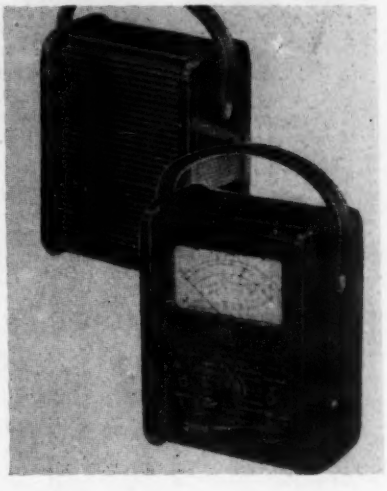


semiautomatic operation. The antenna can be transferred from final to driver stage by a single control switch, making it possible to service the high-power equipment during broadcasting periods.

•

Protective Meter Case (45)

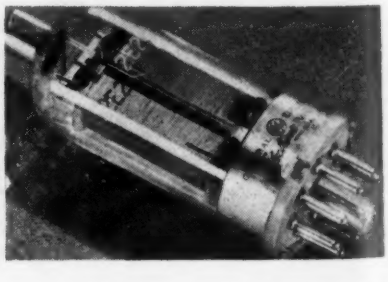
SIMPSON ELECTRIC CO., Chicago, Ill. The well-known model 260 volt-ohm-milliammeter is now available with



a roll-top safety case that completely protects it from damage during periods when it is not in active use.

Mobile Tube (46)

GENERAL ELECTRIC CO., Schenectady, N. Y. The GL-2E24 is a five-electrode beam power tube designed



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1269 Atlantic Ave.
Brooklyn, New York, N. Y.

Tobe Deutschmann Corp.
863 Washington Street
Canton, Mass.

Electronic Corp. of America
353 West 48th Street
New York, N. Y.

Emerson Radio &
Phonograph Corp.
76 Ninth Ave.
New York, N. Y.

General Electric Co.
Bldg. 267; 1 River Road
Schenectady, N. Y.

General Electronics, Inc.
1819 Broadway
New York, N. Y.

Hammarlund Mfg. Co., Inc.
460 West 34th Street
New York, N. Y.

Hytron Radio & Electronics Corp.
76 LaFayette St.
Salem, Mass.

Johanns & Keegan Co., Inc.
62 Pearl St.
New York, N. Y.

Newark Electric Co., Inc.
242 West 55th St.
New York, N. Y.

Radio Parts Distributing Co.
128 West Olney Road
Norfolk, Va.

Smith-Meeker Engineering Co.
125 Barclay Street
New York, N. Y.

Standard Arcturus Corp.
99 Sussex Ave.
Newark, New Jersey

Sylvania Electric Products, Inc.
Emporium, Pa.

Technical Apparatus Co.
165 Washington St.
Boston, Mass.

Tung-Sol Lamp Works, Inc.
95 Eighth Ave.
Newark, New Jersey

W. & H. Aviation Corp.
Municipal Airport
Rochester, New York

MIDWESTERN

American Condenser Co.
4410 N. Ravenswood Ave.
Chicago, Ill.

Belmont Radio Corp.
3633 S. Racine Ave.
Chicago, Ill.

Electro-Voice, Inc.
Carroll & Cecil Streets
Buchanan, Michigan

Essex Wire Corp.
1601 Wall Street
Fort Wayne, Indiana

E. F. Johnson Co.
206 Second Ave., S. W.
Waseca, Minnesota

SOUTHERN

Navigation Instrument Co., Inc.
P. O. Box 7001, Heights Station
Houston, Texas

Southern Electronic Co.
512 St. Charles Street
New Orleans, La.

PACIFIC

Cole Instrument Co.
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Literature

(47)

Strain Measuring. Nosker Engineering Products, Yellow Springs, Ohio. Information and pictures of strain measuring recorders and indicators are found in bulletin 2A-4.

(48)

Crystal Units. Reeves-Hoffman Corp., 321 Cherry St., Carlisle, Pa. Bulletin RHC-3 covers the RH-7B crystal which is available with 3- to 15-mc fundamental, or 15- to 75-mc harmonic mode output frequencies. The RH-9 crystal, designed for television and f-m, is described in bulletin RHC-2.

(49)

Resistance Standards. Rubicon Co., 3614 Ridge Ave., Philadelphia 32, Pa., announce publication of a new 12-page illustrated technical bulletin, No. 100. Operation, application, construction, and other pertinent data on their complete line of resistance standards and resistance bridges are furnished.

(50)

Rectifier for Receivers. General Transformer Corp., 4321 N. Knox Ave., Chicago 41, Ill. Two catalog pages set forth the chief features of the new Perma-Power unit for converting battery radios to all-electric operation.

(51)

Relays. American Relay and Controls, Inc., 2555 Diversey Ave., Chicago 47, Ill., has recently published a 4-page folder on its line of relays, switches, and electrical specialties.

(52)

Audio Appurtenances. Atlas Sound Corp., 1443 39th St., Brook-

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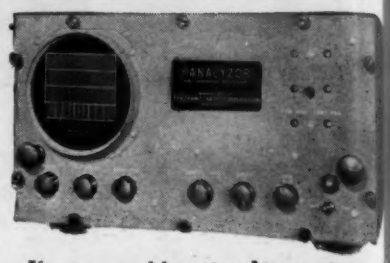

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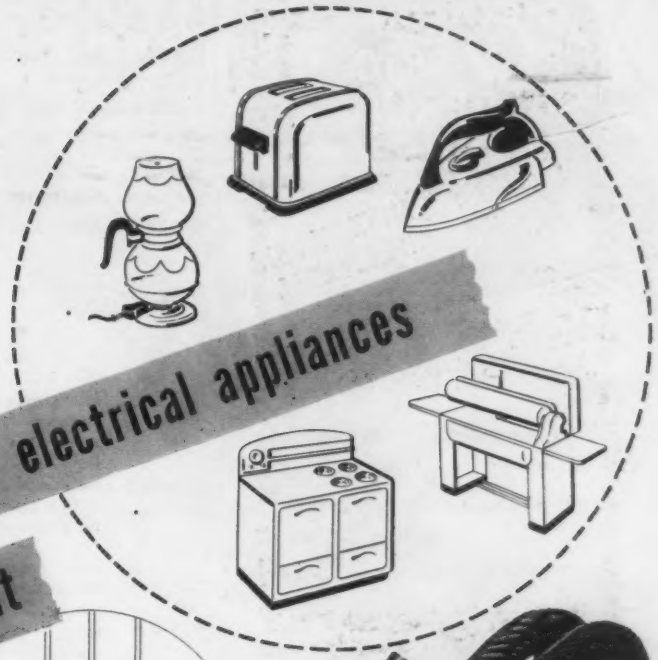

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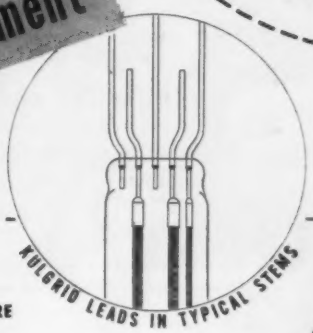

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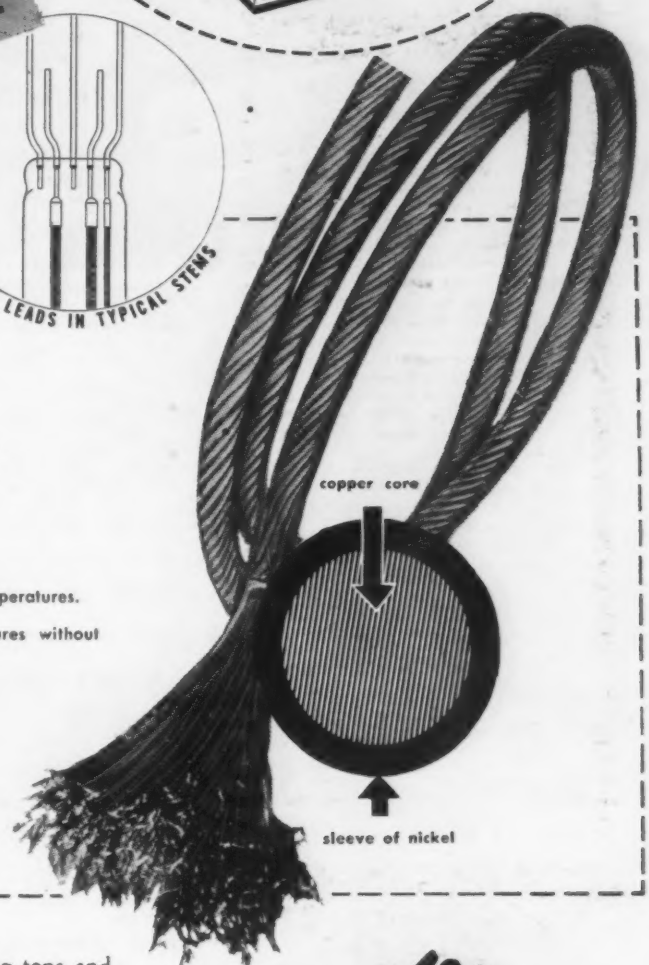

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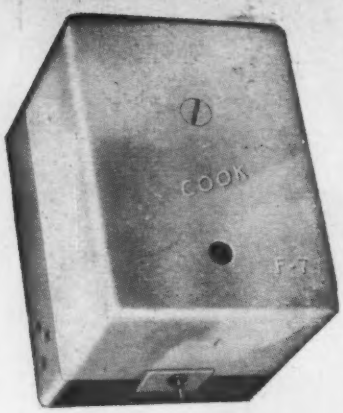

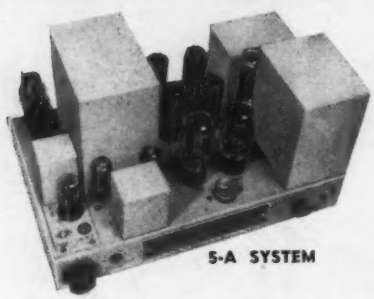

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lyn 18, N. Y. Pages 7 and 8 of Catalog 47 show desk stands, boom stands and arms, bracket clamps, and other necessary adjuncts to the technique of picking up sound with a microphone.

(53)

Coax Relay. Signal Engineering & Mfg. Co., 154 West 14th St., New York 11, N. Y. Bulletin CR1 describes a coaxial cable relay for high-frequency switching. It has a 250-watt capacity and can be used to switch a 75-ohm line, maintaining a low standing-wave ratio.

(54)

Transmitters. Federal Telephone and Radio Corp., 100 Kingsland Road, Clifton, N. J. Three new multichannel communication transmitters, the 184-A, 185-A, and 186-A, designed for ground-to-air and point-to-point service, are described and illustrated in a recent bulletin. Flexible arrangement of basic equipment makes them adaptable for present and future needs.

(55)

Parts Catalog Sheets. Radio Corp. of America, Harrison, N. J. Of special interest to hobbyists and experimenters are the catalog sheets on television parts as well as those on antennas, speakers, and a phonograph modernization kit.

(56)

Transmitting Tetrode. Raytheon Manufacturing Co., Power Tube Division, Waltham, Mass. An 8-page brochure includes a complete set of graphs giving characteristics of the RK-6D22 transmitting tetrode. The tube has 1,000-watt r-f output with 3,000-volt plate supply and 22-watt grid drive. Plate dissipation is 450 watts.

(57)

Rectifier. Sylvania Electric Products Inc., Emporium, Pa. Type 5AZ4 full-wave rectifier ratings and characteristics are presented on a single sheet recently issued.

(58)

Insulated Tubing. Insulation Manufacturers Corp., 565 West Wash-

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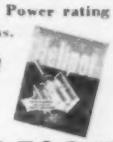

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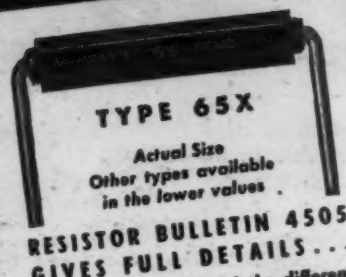

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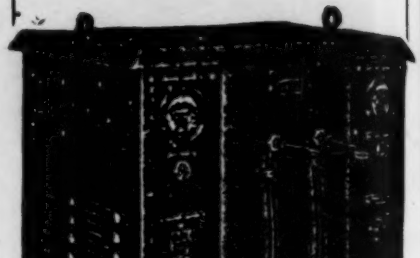

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ington Blvd., Chicago 6, Ill. Dielex cotton and Fiberglas tubing is attractively displayed by means of sample lengths mounted on a folder. A recent price list is included.

(59)

Microwave Test Equipment. Polytechnic Research and Development Co., Inc., 66 Court St., Brooklyn 2, N. Y. Resistive pads and attenuators, slotted lines and probes, frequency meters, and cavities are included in the line of precision microwave components listed in a newly released catalog.

(60)

Miniature Tubes. Radio Corp. of America, Harrison, N. J. Sheets describing types 1U5, 6BJ6 and 12AL5 miniature tubes have just been made available. The tube functions are, respectively, diode-pentode, r-f amplifier pentode, and twin diode.

(61)

Variable Transformers. Superior Electric Co., 277 Church St., Bristol, Conn. Bulletin 547 features Powerstat variable transformers and Stabiline automatic voltage regulators. Ratings, detail drawings, photographs, and engineering data are concisely presented.

(62)

Resonant Relays. Stevens-Arnold Inc., 22 Elkins St., So. Boston 27, Mass. The range of the company's line of resonant relays has been extended to 1,000 cycles, increasing the usefulness of these relays for remote control purposes. Read about it in Catalog 116A.

(63)

Plugs and Jacks. Switchcraft Inc., 1735 West Diversey Parkway, Chicago 14, Ill. A 2-color catalog of 8 pages lists a line of jacks, plugs, and switches. Mechanical drawings, photographs, and material specifications simplify the information for the design engineer.

(64)

Electrolytic Capacitors. Pyramid Electric Co., 155 Oxford, Paterson,

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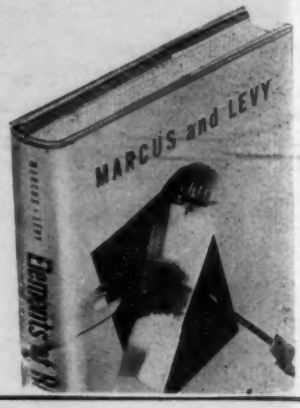

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N. J. Catalog J-4 includes a wide variety of d-c electrolytic capacitors in cardboard and metal containers with capacitances ranging from 5 to 2,000 microfarads at working voltages from 6 to 600 volts.

(65)

Fuses. Littlefuse Inc., 4799 N. Ravenswood Ave., Chicago 40, Ill., offers Catalog No. 9 as an encyclopedia of fusing information and circuit protection, including complete details on fuses, mountings, testers, and accessories.

(66)

Ham Tube Types. Radio Corp. of America, Tube Division, Harrison, N. J. Form No. HAM-103 is a new 4-page folder that charts the ratings, characteristics, operating conditions, and prices of a preferred group of 27 rectifiers, oscillators, amplifiers, and modulators used in amateur transmitters.

(67)

Transmitting and Industrial Tubes. Machlett Laboratories, Inc., Springdale, Conn. An illustrated catalog of power tubes for communications and industry lists characteristics and suggested uses for the company's line.

(68)

Organization Method. Alden Products Co., 117 N. Main St., Brockton, Mass. The Red Book devotes 44 pages to an exposition of the Alden organization and its method of handling development and manufacturing problems.

(69)

R-F Generator. The Clough-Brengle Co., 6014 Broadway, Chicago, Ill. Model 299-A r-f signal generator covers the range from 100 kc to 32 mc in five bands. A complete listing of its qualifications for the job is presented on a single two-page sheet.

(70)

Tube Catalog. United Electronics Co., 42 Spring St., Newark 2, N. J. Each registered holder of a United loose-leaf catalog should have received the latest price list together

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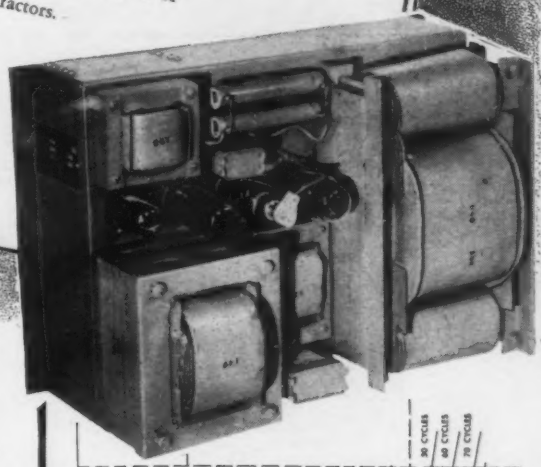

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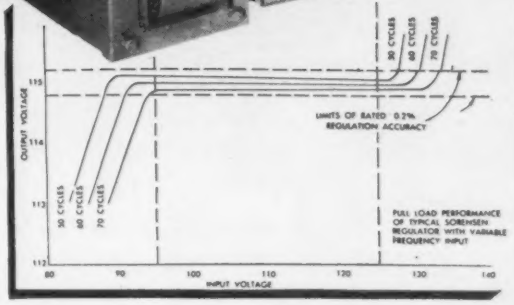

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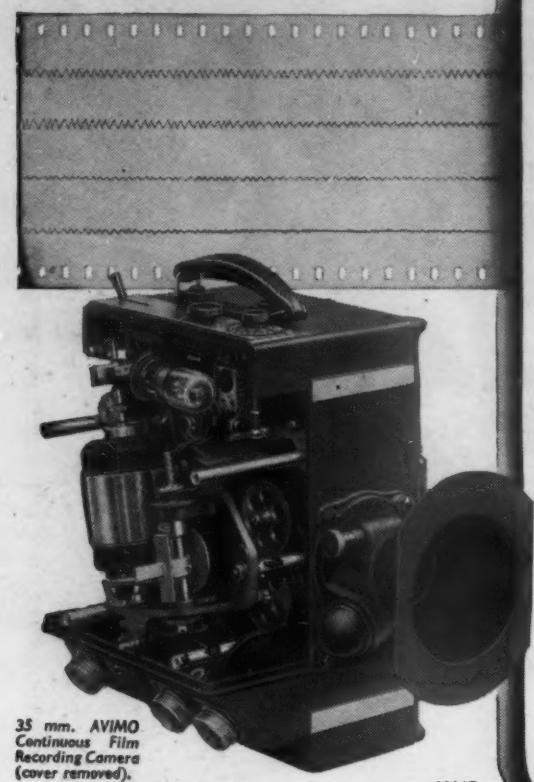

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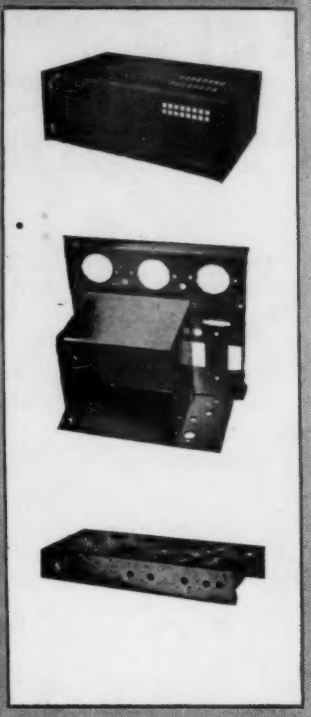

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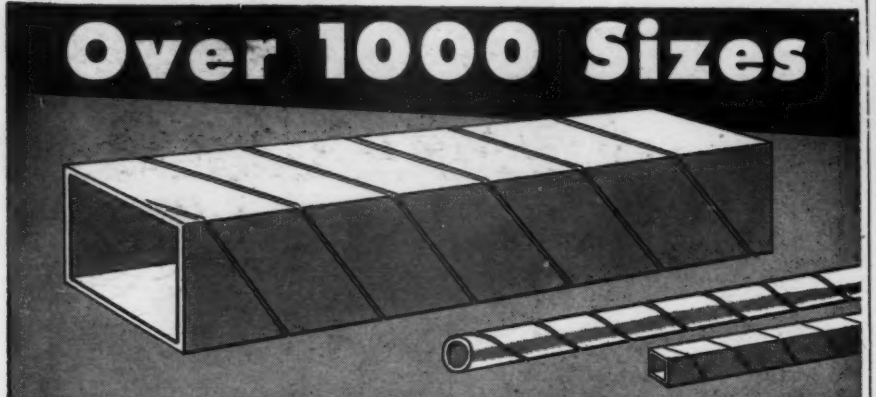

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with data sheets on three industrial electronic tubes just issued.

(71)

Electronic Analyzer. Weston Electrical Instrument Corp., Newark 5, N. J. Model 769 analyzer has been designed primarily for f-m, a-m, and television service work. Circuitwise, it is a type described in the March 1947 issue of ELECTRONICS. A single-page sheet lists its functions and characteristics.

(72)

Catalog Sheets. General Instrument Corp., 829 Newark Ave., Elizabeth 3, N. J. The latest catalog sheets on the new f-m and a-m capacitors, models 2012 and 2022, are now available. Complete electrical and mechanical specifications are given. Along with the sheets, holders of the catalog may obtain a calculator for aid in rapid electrical circuit computations. This too is perforated for easy insertion in the catalog binder.

(73)

Tube Guide. Hytron Radio and Electronics Corp., Salem, Mass. A handy loose-leaf margined reference guide for miniature electron tubes has been compiled and published as a service to users. All miniature types announced to date are included regardless of the originating or producing manufacturers.

(74)

Resistors. Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn 2, N. Y. An informative bulletin, available on request, illustrates and describes the characteristics of cement coating for power resistors.

(75)

Radio Parts. JFD Manufacturing Co., 4117 Ft. Hamilton Parkway, Brooklyn 19, N. Y. In a recently published 44-page catalog, we find described in detail over 4,000 radio parts from battery plugs to antennas.

(76)

Ceramic Capacitors. Centralab Division of Globe-Union Inc., Mil-

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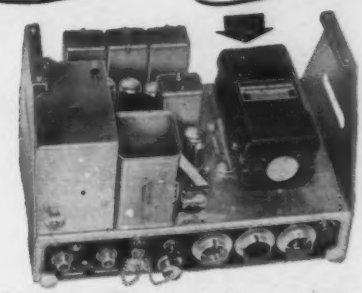

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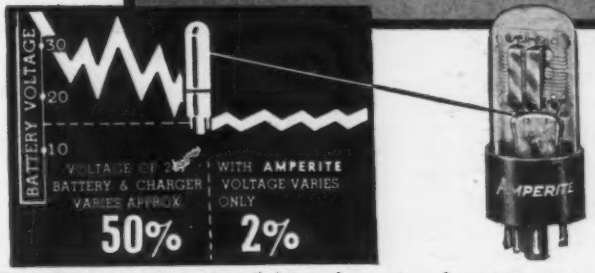

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MODEL 204-A

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SIGNAL GENERATORS

waukee, Wisconsin. Booklet 967 tells of the development, use, and characteristics of tubular ceramic bypass and coupling capacitors.

(77)

Products Catalog. General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill. About 500 items of electronic hardware and radio products are listed by classification groups in the new catalog, No. 3051.

(78)

F-M Antenna. Radio Corp. of America, Camden, N. J. Two sides of a page serve to show the chief features, outlines, and mounting details of the new single-section low-power Pylon antenna, types BF-21A and BF-21B, suitable for f-m broadcast use.

(79)

Rotary Power Supplies. Carter Motor Co., 2664 N. Maplewood Ave., Chicago, Ill., announce release of their latest sales bulletin No. 447-J. Many models of portable converters and dynamotors are illustrated and tables of voltage input and output are included.

(80)

Neutralizing Capacitor. The Hammarlund Mfg. Co. Inc., 460 W. 34th St., New York 1, N. Y. Complete electrical and mechanical specifications about the NZ-10 neutralizing capacitor with a range from about 2 to 11 micromicrofarads are given in a 4-page folder just released.

(81)

Laboratory Report. RCA Industry Service Laboratory, 711 Fifth Ave., New York 22, N. Y. A 20-page brochure describes and illustrates the activities of the radio development and consultation center.

(82)

Automatic Synchronizer. Burlington Instrument Co., Burlington, Iowa. Bulletin SN-400 is fully descriptive of the type SN, model SF automatic synchronizer. The unit is designed for automatically

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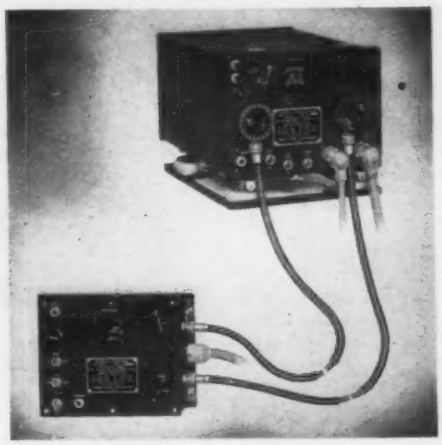

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controlling circuit breaker closure of a-c generators in parallel to a common bus. It is available for either 115- or 230-v, 50 to 60-cycle operation.

(83)

Tube Notes. Radio Corp. of America, Harrison, N. J., has issued two new booklets of application notes. AN-120 gives a thorough treatment of the 6SB7-Y, a pentagrid converter tube with high conversion transconductance. Use of the 6BA6 and 6BE6 miniature tubes in f-m receivers is described in AN-121.

(84)

F-M Transmitters. Radio Corp. of America, Engineering Products Dept., Camden, N. J. In an 8-page booklet chief features of three types of f-m broadcast transmitters are set forth along with pictures of each. Types 250A, 1C, and 3B have a power of 250 w, 1 kw, and 3 kw respectively.

(85)

Microphones and Pickups. Shure Bros., 225 W. Huron St., Chicago, Ill., announce issuance of two publications. Catalog 157 illustrates microphones and acoustic devices; and 158, phonograph pickups and replacement cartridges.

(86)

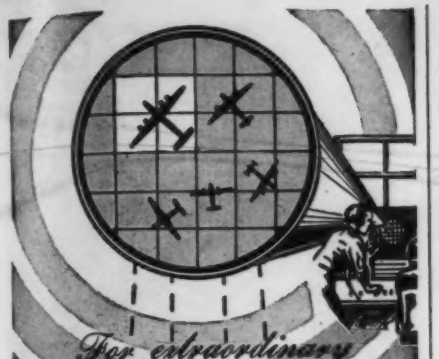
Speakers. Permoflux Corp., 4900 W. Grand Ave., Chicago 39, Ill. A 4-page bulletin covers complete data on over 100 types of speakers. Included are characteristic specifications for all types: sizes, flux density, voice coil diameters and impedance, watts, dimension and recommended transformer sizes.

(87)

Resistance Products. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa. A series of ten new catalog bulletins furnishes the latest technical data on a broad line of resistance products.

(88)

Limiting Amplifier. General Electric Co., Syracuse, N. Y. A 12-page



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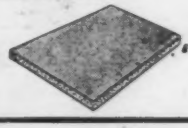
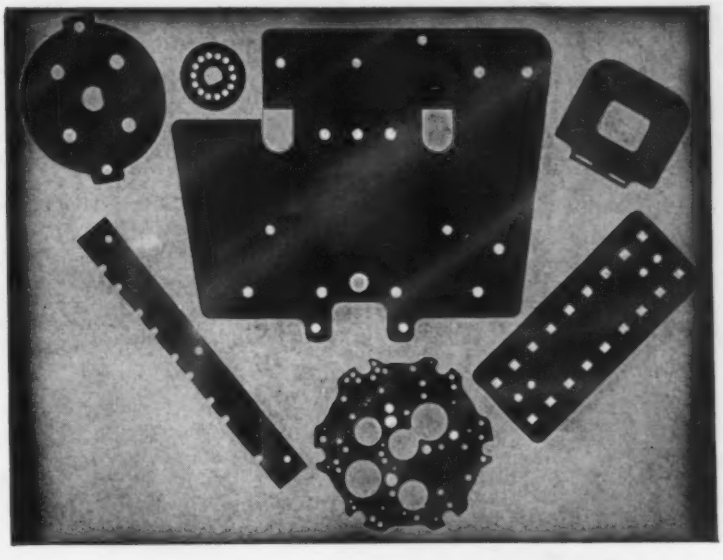


"SKYPLY"



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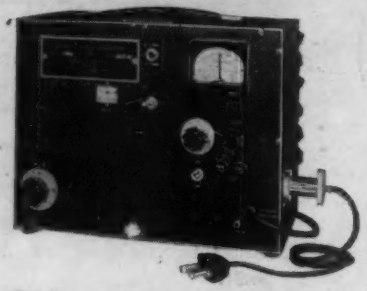

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MODEL 78-FM
RANGE: 86 to 108 megacycles
OUTPUT: 1 to 100,000 microvolts
Individually Calibrated Dial

PULSE GENERATOR
MODEL 79-B
RANGE: 50 to 100,000 cycles
In three ranges
PULSE WIDTH: 0.5 to 40 microseconds
OUTPUT: 150 volts

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Pulse Generators
FM Signal Generators
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Television and FM Test Equipment

Catalog on request

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brochure, EBR-99, on the limiting amplifier, Type BA-5-A, has been prepared. Complete with schematic drawings and diagrams, it lists the operational and constructional features of the amplifier, a unit designed to increase the average program level of broadcasting and recording systems without danger of any audio peak exceeding a predetermined maximum value.

(89)

Controlled Music. Tel-O-Matic Products, Inc., 304 Clifton Ave., Clifton, N. J. Two pamphlets completely describe and illustrate the new musical robot. A 35-w peak power, 3-channel distribution amplifier permits radio reception, planned recorded music or microphone loudspeaker unit. Each channel input is fully controllable from the front panel.

(90)

Graphic Instruments. The Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis 6, Indiana, has a list of about fifty bulletins describing a variety of graphic instruments and their applications. The listing or any of the individual publications are free to engineers and executives.

(91)

Relays. Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12, Ill. Many basic a-c and d-c relays are illustrated in Catalog No. 10-A, with diagrams, charts giving operating and contact data, and suggested applications for each relay.

(92)

Wires and Cables. Lenz Electric Mfg. Co., 1751 North Western Ave., Chicago 47, Ill. Catalog No. 31 is a 16-page booklet that describes and illustrates a wide variety of wires, cords, and cables for radio, hookup, antenna, intercommunication, and similar use.

(93)

X-Ray Diffraction. North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y. Folder R1063 describes the principles of

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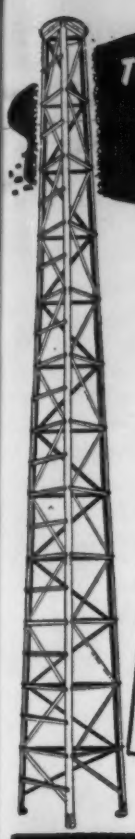

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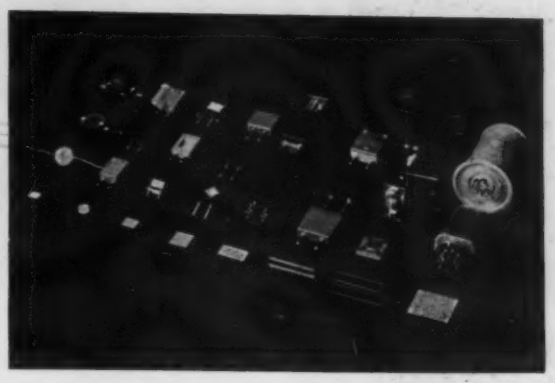

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x-ray diffraction and its use in industrial control. Also available gratis on request are two reprint leaflets entitled "Sampling Techniques Applied to Quality Control" and "Metallurgical Applications of the X-Ray Difraction Spectrometer".

(94)

Voltage Calibrator. Allen B. DuMont Laboratories, Inc., Passaic, N. J. A one-page reprint describes the type 264-A voltage calibrator which is independent of line-voltage variations and can be used with any oscillograph. A descriptive bulletin will be sent on request.

(95)

Chronotron Tube. Bendix Aviation Corp., Eclipse-Pioneer Division, Teterboro, N. J. This temperature - resistance device, mounted in a miniature-size vacuum-tube envelope, was developed primarily for use in electronic control circuits providing time delay and functioning as an integrator. A complete description, together with diagrams and tables, is found in bulletin 73-3A.

(96)

Rotary Switch Catalog. United States Instrument Corp., 19 South Harrison St., East Orange, N. J. An 8-page illustrated catalog describes the various types of rotary selector switches manufactured, besides giving dimensional drawings of representative types.

(97)

Flow-Rate Meter. Fischer and Porter Co., Hatboro, Pa., has issued a new bulletin describing and illustrating instruments for measuring flow rate of liquids and gases. Write for a copy care of Dept. 2N-C.

(98)

Remote Control. Yardeny Laboratories, Inc., 105 Chambers St., New York 7, N. Y. Typical remote control systems are described in this six-page booklet. These everyday applications are particularly valuable for planes, ships and moving vehicles as well as two-wire systems.

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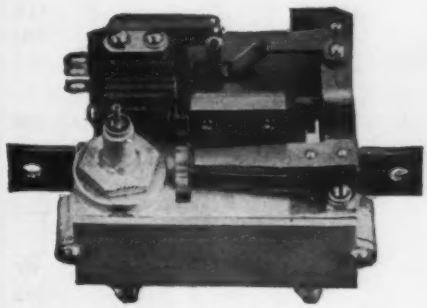

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(continued from p 146)

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THE FIRST issue of Nucleonics, a new McGraw-Hill monthly devoted to the peaceful uses of nuclear fission, made its appearance in September. The publication covers the field of nuclear technology, as distinct from that of nuclear science, and will provide information on industrial, medical, and other applications of atomic power and its byproducts. Subscription price is $15 per year. It will carry no advertising.

Included in the initial issue were articles by Drs. E. U. Condon, Clark Goodman, R. D. Evans, W. Radin, L. J. Rainwater, and C. S. Wu, as well as a statement from the Atomic Energy Commission, a list of declassified Manhattan District technical papers, and another on available radioisotopes.

The editorial staff, headed by Keith Henney as editor, includes Walter M. DeCew, formerly of the Los Alamos project. Drs. John Dunning and H. H. Goldsmith are advisors.

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MONDAY NOV. 3—MORNING

Keynote address by President G. D. Stoddard of the University of Illinois.

Electronics Comes of Age, by Dr. L. V. Berkner of the Joint Research and Development Board.

Luncheon Speaker—W. Evans, vice-president of Westinghouse Electric Co.

MONDAY NOV. 3—AFTERNOON

1. NOISE SUPPRESSION AND DISTORTION

Dynamic Noise Suppressor, by H. H. Scott of Technology Instrument Corp.

Intermodulation Method of Distortion Measurement, by W. J. Warren of U. of Santa Clara and W. R. Hewlett of Hewlett-Packard Co.

S/N Ratio in AM Receivers, by E. C. Fubini and D. C. Johnson of Airborne Instruments Lab., Inc.

Corona Discharge at High Altitude and Low Temperature, by H. J. Dana of State College of Washington.

2. ELECTRONIC INSTRUMENTATION—Chairman: M. F. Behar, Editor of Instruments.

Self-Balancing Thermistor Bridge, by C. C. Bath and H. Goldberg of Bendix Radio Corp.

Variable Ratio Inductance Bridges and Networks, by Paul Glass and Sylva May Dushkes of Askania Regulator Co.

A Miniature Gastro-manometer for Electrical Recording, by H. C. Roberts of University of Illinois.

Short-Time Oscillography, by Jean V. Lebacqz of Johns Hopkins University.

Luminescent Screens For Cathode-Ray Oscillography, by Carl Feldt of DuMont.

3. COAXIAL ELEMENTS AND MICROWAVES

Bead Supported Coaxial Attenuator (4,000 to 10,000 mc), by John W. E. Griemsmann and Herbert J. Carlin of Microwave Research Institute, Polytechnic Institute of Brooklyn.

Wave Propagation in Beaded Lines, by R. E. Beam of Northwestern University.

Coaxial Elements and Connectors, by W. R. Thurston of General Radio Co.

Broadband Matching of Impedances, by R. M. Fano of MIT.

Broadband Bolometer Type U.H.F. Power Meters, by M. J. DiToro of Polytechnic Institute of Brooklyn.

4. OPERATION OF ELECTRONIC RESEARCH—Chairman: J. E. Hobson, Armour Research Foundation.

Organization and Operation of Electronic Research, by R. M. Bowie of Sylvania Electric Co.

Electronic Research in the University, by L. T. DeVore of University of Illinois.

Electronic Research in the Research Institute, by G. E. Zeigler of Midwest Research Institute.

Electronic Research in the Government Service, by Archibald S. Brown of Wright Field.

Banquet and Floor Show—Marine Dining Room.

TUESDAY NOV. 4—MORNING

5. MICROWAVES

Higher Mode Techniques for Wave Guides, by M. W. Goodhue of Polytechnic Research and Development Co.

Multiplex Transmission Through Wave Guides Using Higher Order Modes, by R. R. Buss, W. A. Hughes, H. D. Ross, and A. B. Bronwell of Northwestern University.

Microwave Spectroscopy, by D. K. Coles and W. E. Good of Westinghouse Electric Corp.

Noise Reduction in Radar and Communications, by S. Goldman of MIT.

6. Joint session of National Electronics Conference and AIEE, program arranged by AIEE.

7. COMPUTERS

Electronic Computers, by J. W. Mauckly and J. P. Eckert Jr. of Electronic Control Co.

Storage of Numbers on Magnetic Tape, by J. M. Coombs of Engineering Research Associates.

Computers for Aeronautical Navigation, by Hugo Schuck of Minneapolis-Honeywell.

8. ELECTRONIC CIRCUIT ANALYSIS I Cathode Tap, Cathode Follower Ampli-

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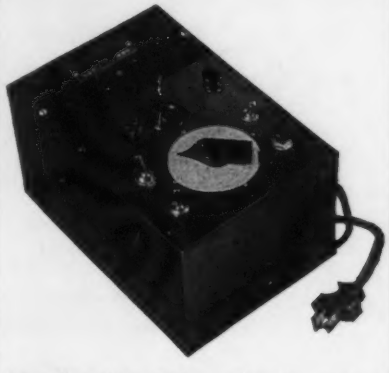

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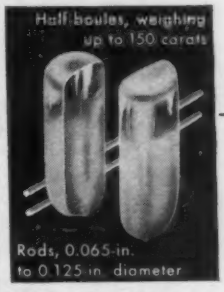
SYNTHETIC SAPPHIRE For Resistance to All Commercial Chemicals

If corrosion resistance of small parts is important to your product, it's worthwhile to consider LINDE synthetic sapphire. This new raw material resists chemical attack and wear. It has high electrical resistance—low thermal conductivity.

1. Chemical Resistance . . All acids
2. Hardness (Knoop) 1,525 to 2,000
3. Thermal Conductivity . . 0.015 (cal. sec.$^{-1}$ cm^{-1} deg. C.$^{-1}$ at 500 deg. C.)
4. Dielectric Constant . . . . . 7.5 to 10



Send for Data Sheet No. 5 for all the specific properties of this advantageous material—LINDE synthetic sapphire.

THE LINDE AIR PRODUCTS COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.
In Canada:
Dominion Oxygen Company, Limited, Toronto

The word "Linde" is a trade-mark of The Linde Air Products Company

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THERE'S A DRAKE SOLDERING IRON FOR EVERY TYPE OF ELECTRONIC WORK

From that mighty mite

the Drake No. 400 to the high-speed production "honey"

the Drake No. 600-10 there is a high quality Drake Soldering Iron "just right" for the job.

Drake Heat Controls and the Drake "Magic Cup" Stand are important soldering aids.

SEE YOUR RADIO PARTS JOBBER

DRAKE ELECTRIC WORKS, INC.
3656 LINCOLN AVE. CHICAGO, ILL.

MODEL No. 301-A

MILFORD FASTENING EQUIPMENT

HAVE YOU **ASSEMBLIES** LIKE THESE?

Heating Equipment
Small Animal Cages
Industrial Baskets
Baby Carriages *Stoves*
Leather Goods, etc., etc.

Assemblies cost more than you think. Not the material, but the time to complete them. Check time costs and you will be startled. Milford knows—from checking time costs for innumerable manufacturers. That's why they chose Milford Fastening Equipment (semi-tubular or split rivets and rivet setters). It flattens the time-cost curve, assures proved and important savings on assemblies as diverse as wrist-watches and refrigerators. Don't delay. Investigate today. Deliveries are not yet normal. Earliest ordered, earliest delivered.

The Milford Rivet & Machine Co.
859 Bridgeport Avenue, Milford, Conn.
1002 West River Street, Elyria, Ohio

Inquiries may also be addressed to our subsidiary:
THE PENN RIVET & MACHINE CO., PHILADELPHIA 33, PENNA.

BRADLEY

PHOTO ELECTRIC CELLS

Unmounted Cells

The shapes of Luxtron photocells vary from circles to squares, with every in-between shape desired. Their sizes range from very small to the largest required.

In addition to the unmounted cells shown here, Bradley also offers cells in a variety of standard mountings, including plug-in and pigtail types.

For direct conversion of light into electric energy, specify Bradley's photocells. They are rugged, lightweight and true-to-rating.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

fiers, by Bradford B. Underhill of Penn State College.

Low Power Frequency Multipliers, by R. J. Schwarz of Columbia U.

Series Mode Quartz Crystal Oscillator Circuit, by H. Goldberg and E. L. Crosby, Jr. of Bendix.

Luncheon: An American Engineering Association, by B. D. Hull, Chief Engineer of Southwestern Bell and President of AIEE.

TUESDAY NOV. 4—AFTERNOON

9. NEW DEVELOPMENTS

Ultrasonic Guidance of the Blind, by Frank H. Slaymaker and W. F. Meeker of Stromberg-Carlson Co.

Heatless Preservation with Penetrating Electrons from the Capacitron, by W. Huber of Electronized Chemicals Corp.

Citizen's Radio Service, by R. E. Samuelson of Hallicrafters.

General Trends in Foreign Electronic Developments, by A. H. Sullivan Jr. of Wright Field.

10. INDUSTRIAL ELECTRONICS

Electronic Half-Tone Engraver, by John Boyajian of Fairchild Camera and Instrument Corp.

Electronic Servomechanism Testing Machine, by H. W. Katz of U. of Illinois.

Sealed Ignitrons for Radio Transmitter Power Supplies, by H. E. Zuvers of G-E.

Single Phase Controlled Rectifier and Inverter Circuits, by C. M. Wallis of U. of Missouri.

11. ANTENNAS

High Gain with Discone Antennas, by A. G. Kandoian, W. Sichak, and R. A. Felsenheld of Federal Telecommunication Lab.

Slot Antennas, by N. E. Lindenblad of RCA.

Measurement of Aircraft Patterns in Flight, by J. S. Prichard of Airborne Instruments Lab.

Transmission Frequencies for Line of Sight Systems, by L. S. Schwartz of NRL.

12. NUCLEONICS

Mass Spectrometer Type Leak Detector, by Robert F. Wall of Texas A. and M. College.

Scintillation Counter, by J. W. Coltman of Westinghouse.

Precision Studies of Nuclear Reactions, by W. E. Shoupp of Westinghouse.

WEDNESDAY NOV. 5—MORNING

13. MILITARY APPLICATIONS OF ELECTRONICS

Guided Missiles, by Walter N. Brown Jr., of Haller, Raymond and Brown.

Telemetry System for Guided Missiles, by L. J. Neelands and Walter Hausz of G-E.

Foreign Developments in Infrared, by E. A. Underhill of Wright Field.

Foreign Vacuum Tubes and High Frequency Techniques, by B. L. Griffing of Wright Field.

14. COMMUNICATIONS

Teleran, A Technical Progress Report, by R. W. K. Smith, D. H. Ewing, and H. J. Schrader of RCA.

Crystal Saver, by W. R. Hedeman Jr. of Bendix Radio Corp.

Pulse Count Modulation, by D. D. Grieg and S. Metzger of IT&T.

Air-Traffic Control, by W. D. White of Airborne Instruments Lab.

15. BASIC SCIENCE

Semi-Conductors, by K. Lark-Horovitz of Purdue U.

Dynamic Properties of the Infrared Cesium Arc, by J. M. Frank and W. S. Huxford of Northwestern U.

Supersonic Detection of Infrared Modulation, by F. J. Fry and W. J. Fry, U. of Illinois.

Microwave Scattering, by R. T. Gabler of Westinghouse.

16. INDUSTRIAL APPLICATIONS

High Frequency Operation of Fluorescent Lamps, by J. H. Campbell and B. D. Bedford of G-E.

Magnetostriction Torquemeter, by C. M. Rifenberg and E. H. Schulz of Armour Research Foundation.

Saturable Core Magnetometer Applications, by W. E. Tolles of Airborne Instruments Lab.

WEDNESDAY NOV. 5—AFTERNOON

17. TELEVISION

The Chromoscope, A New Color Television Viewing Tube, by A. B. Bronwell of Northwestern U.

Color in Television Cathode Ray Tubes, by E. B. Fehr of G-E.

A Modern Television Transmitter, by C. D. Kentner of RCA.

Monitoring Equipment for Television

POLARAD TELEVISION Equipment

for studio • laboratory • manufacturer

PICTURE & WAVE FORM MONITOR

Model M102

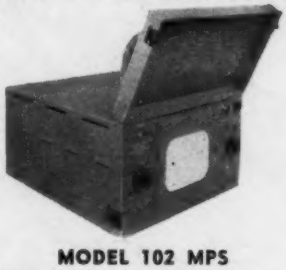
FEATURES:

- Resolution greater than 600 lines.
- 10" Kinescope and 5" oscilloscope.
- Built-in Bar Generator for checking horizontal and vertical linearity.
- Horizontal and Vertical Pulse Cross phaseable over entire Kinescope.
- All controls accessible from front of rack.
- All parts readily accessible for quick servicing and testing.
- Monitor section occupies 17½"x19" panel space and may be mounted at a remote point.
- Video input high impedance.
- May be operated by either driven or composite signals.
- Voltage calibrator for Wave Form Monitor.

Specifications

Input impedance of Picture Monitor 470,000 ohms.
Picture Amplifier: Flat to 7.5 Mc ± 1 db.
Scope Amplifier: Flat to 3. Mc ± 1 db.
Input Signal: 1 Volt peak to peak.
115 volts 50/60 cycles—6 amps.
Complete with tubes in a rack 83"x22"x21".

Portable Picture Monitor



MODEL 102 MPS

FEATURES:

- Resolution 500 lines.
- 7" Kinescope.
- High Impedance Input.
- Rugged construction.
- Size 9"x16"x20", weight 50 lbs.
- Kinescope removable from front and all parts are readily accessible.

SPECIFICATIONS:

- Input Impedance 470,000 ohms.
- Video Amplifier: Flat to 5 Mc ± 1 db.
- Input Signal: 1 volt peak to peak.
- 115 volts 50/60 cycles.
- Complete with tubes.

Dual Portable Picture Monitor

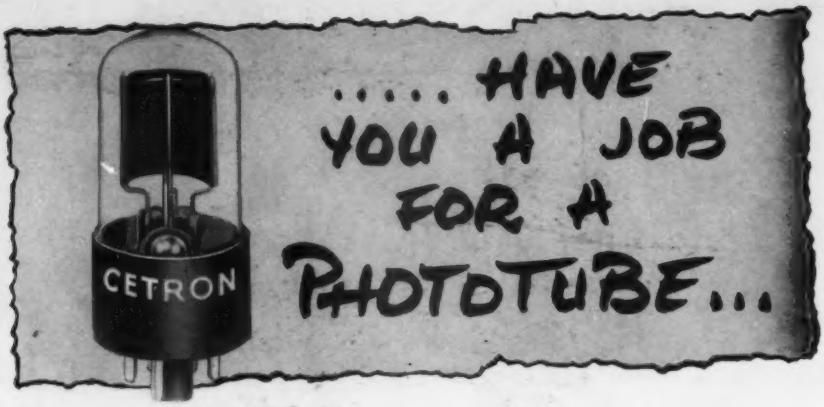
MODEL 102 MPD

This unit has the same performance and constructional features as the single portable monitor. This unit is supplied in two carrying cases consisting of a control unit and the dual monitor unit. Each monitor may be used independently of the other.

Polarad Electronics Company

9 FERRY STREET, NEW YORK 7, N. Y.

Television engineers and consultants to the nation's great television stations.



Phototubes are doing all sorts of important industrial jobs, in all types of industries . . . speeding up production . . . saving time and labor. Due to our pioneering and intensive research in this field, we are especially well equipped, not only to supply you with the phototubes you need, but to advise you on how to use them efficiently.

Without obligation, send for our special phototube brochure and any information you need.

CONTINENTAL ELECTRIC CO.

Geneva, Illinois

103

MIDGET *coils*

for High-Frequency Application

Have a look at B & W Miniductors when it comes to choosing a midget coil for that next high-frequency application! They're inexpensive—they come in a variety of standard sizes and pitches—they lend themselves readily to all sorts of adaptations—and B & W "Air-Wound" construction assures peak Q factor because there's an absolute minimum of insulation material in the electrical field. Ideal for band-switching assemblies.

Miniductor Bulletin 78C gladly sent on request.

BARKER & WILLIAMSON, Inc.

237 Fairfield Ave., Upper Darby, Pa.

Broadcast, by M. Silver of Federal Telecommunication Lab.

18. ELECTRONIC INSTRUMENTATION II
High Resolving Power Infrared Recording Spectrometers, by R. C. Nelson and W. R. Wilson of Northwestern U.
The Phase Meter, by E. O. Vandeven of G-E.
Accurate Measurement of Relative Phase, by R. Glaser of MIT.
A Null Method for Determination of Impedance in the 100-400 mc Range, by J. F. Byrne of Airborne Instruments Lab.

19. FM BROADCAST DEVELOPMENT
A 50 kw FM Broadcast Transmitter, by C. J. Starner of RCA.
A Pulse-Counter Type FM Station Monitor, by David Packard and Norman B. Schrock of Hewlett-Packard Co.
Transatlantic FM Transmission, by L. B. Arguimbau and J. Granlund of MIT.
Phase Modulation Circuit, by S. M. Beleskas of RCA.

20. ELECTRONIC CIRCUIT ANALYSIS II
Analysis of Oscillator Frequency Instability, by F. P. Fischer of U. of Connecticut.
Transient Behavior in Non-Linear Systems, by Carl S. Roys of Syracuse U.
Calculation of Operating Characteristics of Electromagnetic Devices, by R. M. Soria of American Phenolic Co. and T. J. Higgins of Illinois Institute of Technology.

New IRE Officers

B. E. SHACKELFORD, manager of the license department of RCA International Division, New York, N. Y., has been nominated as president of IRE for 1948. Election returns will be final Oct. 24, 1947.

R. L. Smith-Rose, superintendent of the radio division of the National Physical Laboratory, Teddington, England, has been nominated as vice-president.

In addition, a number of regional directors will be elected, and two directors-at-large for 1948-1950 will be elected from the following nominees: B. deF. Bayly, consulting engineer at the University of Toronto; A. B. Chamberlain, chief engineer of Columbia Broadcasting System; J. E. Shepherd, research engineer for Sperry Gyroscope Co.; J. E. Stratton, professor of physics and director of the research laboratory of electronics, MIT.

Phone Service on Trains

FOR THE first time in the United States, passengers on certain trains of the Baltimore and Ohio Railroad and the Pennsylvania Railroad, between Washington and New York, are able to call and receive calls from any telephone connected with the Bell System while the trains are in motion.

Telephone service will be available for public use initially on the B & O's "Royal Blue" and the Pennsylvania's "Congressional Limited" in both directions between Wash-

SAVE MONEY... USE FEDERAL SHORT RUN STAMPINGS

Whenever you need accurate high quality stampings from almost any material, specify FEDERAL stampings. You are sure to be pleased, and you will save money too!

FASTER DELIVERIES SAVE YOU TIME!

Speedy shipments save you valuable time on design changes or important experimental work. Helps you make faster deliveries on special orders.

SEND FOR FREE BULLETIN TODAY

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TOOL & MFG. COMPANY
3216 Wash. Ave. N., Minneapolis 12, Minn.

ABSOLUTE RESOLUTION

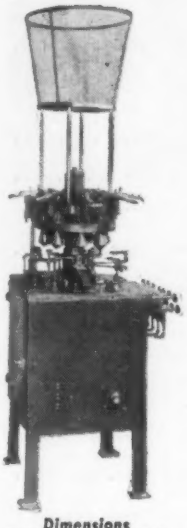
OF 0.06%
for Pressure Measurement

Fairchild Precision Linear Potentiometer

This is actual performance data of Fairchild's low torque Linear Potentiometer—a small precision instrument of 5,000 ohms overall resistance. *Application:* Telemetering extremely accurate electrical pressure measurements from 0" to 100" Hg abs. *Sensitivity:* Absolute resolution of 0.06% (from 1,600 turns on a single-turn mandrel) and 0.12% linearity. *Dependability:* Sustained linearity over several million pressure fluctuations. *Construction:* Precision engineered for quantity production with long-life gold, platinum and silver alloy contacts. For complete data address: Dept. 'F', 88-06 Van Wyck Boulevard, Jamaica 1, New York.

Fairchild CAMERA AND INSTRUMENT CORPORATION

BAACH-INTERNATIONAL



Dimensions 24"x24"x72" high

EIGHT HEAD HOT-CUT FLARE MACHINE

- Automatic throughout.
- Can be synchronized with automatic Stem machine.
- Cuts off and flares in one operation.
- Production 1250 flares per hour. For miniature flares, fluorescent starters, standard size lamps, fluorescent and radio tubes.

RANGE OF MACHINE

Glass tubing 27 to 45 gauge

Length of flares 5 mm. to 80 mm.

Forms flares up to 47 mm. diam.

Net weight, 960 lbs. Gross weight 1450 lbs.

INTERNATIONAL MACHINE WORKS

Manufacturers of High Vacuum Pumps, Automatic Machinery for Incandescent Lamps, Electronic Tubes since 1916.

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NORTH BERGEN, N. J., U. S. A.
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Cable Address "Intermach" North Bergen, N. J.

G-E Variable Reluctance Pickup

CHECK these characteristics of the G-E Variable Reluctance Pickup against your present reproducer head. Make your own exacting tests. Prove to yourself that this pickup will improve the reproduction quality given by your own phonographs.

The G-E Variable Reluctance Pickup has:

- **No resonant peaks.**
- **Wide frequency response—essentially flat from 30 to 8000 cycles.**
- **High compliance of the stylus—hence more faithful reproduction and exceptionally low record wear.**
- **Self protecting genuine sapphire stylus.**
- **Virtual freedom from "needle talk".**
- **Practical insensitivity to vertical vibration—the source of surface noise.**
- **Stability under humidity, heat and cold.**

We are equipped to make prompt delivery to meet your production schedules. For complete information on this finer pick-up write *General Electric Company, Electronics Park, Syracuse, N. Y.*

GENERAL ELECTRIC

168-F4

FOR FASTER SOLDERING
2 NEW WELLER
SOLDERING GUNS
with
Solderlite

The new Weller Soldering Guns with Solderlite plus the fast 5 second heating help make service work more profitable for radio-television and appliance service men, electrical maintenance men, electric motor rewinding and repair shops automotive electrical service. A useful and time-saving tool for laboratory workers, experimenters, hobbyists, telephone installation and maintenance men. See your radio parts distributor or write for bulletin direct.

806 Packer St., Easton, Pa.

WELLER
MANUFACTURING CO.
In Canada: Atlas Radio Corp., Ltd., 560 King St., N. W., Toronto, Ont.
Export Dept.: 25 Warren St., New York 7, N. Y.

ington and New York, via Baltimore, Wilmington and Philadelphia. On August 22 the service was expanded to include Pennsylvania's "Potomac" from Washington to New York and "The Legislator" from New York to Washington.

A portion of the lounge car on each train has been redesigned and set aside for the new telephone service, and will afford privacy to passengers using it. Attendants will locate persons on the train who are being called. The new radio-telephone equipment, designed by the Bell Telephone Laboratories, utilizes one channel for sending and the other for receiving, so that conversations may be carried on in the same way as on a regular telephone call.

Telephone service from each train will be on the same basis as mobile radio-telephone service provided by the Bell System for motor vehicles and other mobile units, and the same rates will apply.

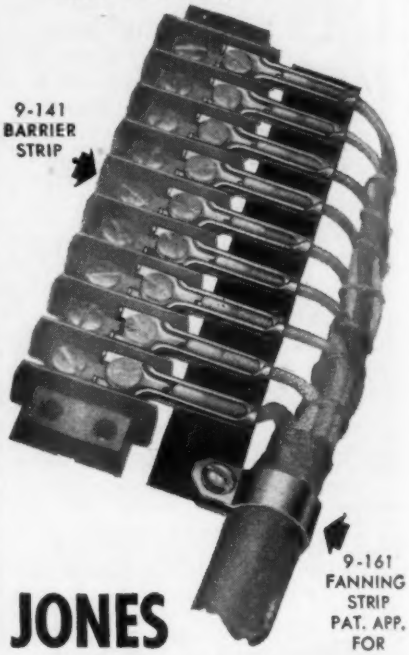
Another pioneer undertaking, though in a different category, is the application of the Chesapeake & Ohio Railway Co. for authority to construct and operate a system which would offer induction public telephone service with certain of its passenger trains en route between Orange, Va., and Cincinnati, Ohio. The estimated cost is $358,900. According to an FCC release, the railroad is of the opinion that "although direct telephone revenues may not result in an immediate profit to the applicant, the overall benefits of the project will result in increased revenues from applicant's transportation business, and will, therefore, be economically justified."

F-M Educational Networks

ACCORDING to a recent FCC survey, 23 states indicated active interest in establishment of statewide f-m educational networks. In acting upon applications for noncommercial educational f-m stations, the Commission considers carefully how the proposed stations will fit into any statewide plan for educational f-m. Construction of a sufficient number of such f-m facilities throughout a state would bring every school and home in the state

New Improvement in TERMINAL WIRING

Connections made through Fanning Strip on bench or anywhere apart from barrier strip, and quickly slipped into assembly.



JONES FANNING STRIP

Designed for use with JONES BARRIER TERMINAL STRIPS No. 141 and No. 142, for one to twenty terminals.

- Simplifies and facilitates soldering. No complications.
- Insures correct, positive, and firm connections. The *right* wire to the *right* terminal *everytime*.
- Time Saving—Speeds up assembly.
- Ideal for harness or cable assembly.
- Strong construction. Brass terminals cadmium plated. Heavy bakelite mounting.

Send for complete data on this new basic improvement.

Mfd. by
HOWARD B. JONES DIVISION
Cinch Manufacturing Corp.
2460 W. George St., Chicago 18, Illinois

MAILING LISTS THAT WORK...

McGraw-Hill Industrial Mailing Lists are a direct route to today's purchase-controlling executives and technicians in practically every major industry.

These names are of particular value now when most manufacturers are experiencing constantly increasing difficulty in maintaining their own lists.

Probably no other organization is as well equipped as McGraw-Hill to solve the complicated problem of list maintenance during this period of unparalleled changes in industrial personnel. These lists are compiled from exclusive sources, based on hundreds of thousands of mail questionnaires and the reports of a nation-wide field staff, and are maintained on a twenty-four hour basis.

Investigate their tremendous possibilities in relation to your own product or service. Your specifications are our guide in recommending the particular McGraw-Hill lists that best cover your market. When planning your industrial advertising and sales promotional activities, ask for more facts or, better still, write today. No obligation, of course.

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Compact...

PLUG-IN SENSITIVE RELAYS

NEW FEATURES OF THIS DESIGN:

- Fits octal socket.
- Outline dimensions: 1¼" x 1¾" x 2" above socket. Permits lining up contiguous relays as close together as the smallest octal sockets will permit.

Features of All SIGMA Series 41 Relays:

- DC sensitivity: — 0.020 watts (min. input.)
- AC sensitivity: — 0.1 volt-ampere (min. input.) One standard 110 volt AC model draws about 1.5 milliampere.
- Contact ratings up to 15 amperes on low voltage.
- High quality construction — mechanically rugged.
- Very low cost.

SIGMA

SIGMA sales and engineering departments are ready to give your relay problems prompt analysis and action.

Sigma Instruments, INC.
Sensitive RELAYS
62 Ceylon St., Boston 21, Mass.

ALNICO
permanent
MAGNETS

- Specialists in the production of highest grade Alnico Magnets.
- Production and material rigidly inspected to assure highest uniform quality.
- Castings made to order from customer's blueprints or sketches.
- Information and suggestions supplied on request.

Manufacturers of High Coercive Magnetic Alloys

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GENERAL
G·M
ALNICO
MAGNETIC CORPORATION

"away ahead"

"...in a comparison check, the BUD VFO-21 is away ahead in stability..."

WRITES

Edward Zimmerman W4FNQ

He says: "The performance of the VFO-21 is very satisfactory in every respect. In a comparison check with the Bud and one selling for a little more than twice as much money, the Bud is away ahead in stability.

In using the VFO-21 "as is", into a mediocre antenna system on 40 meters, I have been able to work consistently into Cuba, the Bahamas and around the state, the tone reports being almost invariably T9X. Its use in conjunction with my final amplifier, (push-pull) 807's at 150 watts input) is entirely satisfactory, the output being enough to overdrive the 807's."

It is unsolicited letters like this from our satisfied customers that convince us that the BUD VFO-21 is an instrument that belongs in your shack.

The BUD VFO-21

Your Cost $52.50

1. **Compact and entirely self-contained.**
2. **Stability comparable to crystal.**
3. **Plug-in coils for highest efficiency.**
4. **A dual purpose unit having V-F-O operation, with provision for switching to crystal operation.**

See it at your local distributors

BUD

BUD RADIO, INC.

CLEVELAND 3, OHIO

within reach of at least one station.

In 1945 the Commission prepared to reserve 20 f-m channels between 88 and 92 mc for educational service. As of July 15, 1947, 9 commercial educational f-m broadcast stations were in operation on the air, 32 construction permits were outstanding, and 8 applications were pending.

The Iowa State College of Agriculture & Mechanical Arts, Ames, Iowa, received the first construction permit for a noncommercial television broadcast station. No other educational institutions hold television authorizations.

Of the 32 licensed standard broadcast stations operated today by schools and colleges, 20 are on a nonprofit basis.

Soviet Television

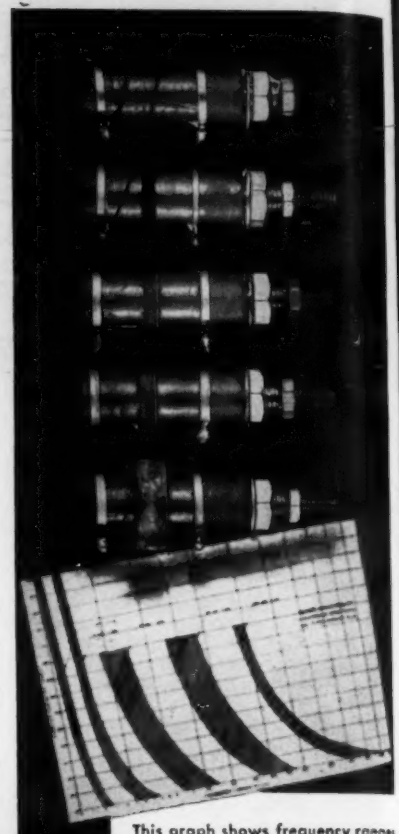
McGraw-Hill World News

TO DEVELOP television in the U.S.S.R., the Moscow television center is to be reconstructed so as to broadcast images with a frequency of 625 lines, instead of 343 lines as before, and new television centers are to be built in Leningrad, Kiev, and Sverdlovsk.

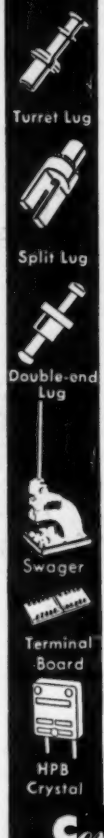
The television centers are to have an approximate range of 40 miles. Sound channels will use f-m. The Moscow television center has been operating since December 1945. Last year it broadcast over 100 shows and fifty movies.

Before the end of this year, production of three types of 625-line television receivers is to be started. There will be a table receiver with a 7-inch tube; a table receiver with a 9-inch tube; and a console receiver with a 12-inch tube. The smallest set will be manufactured on a mass scale.

Research objectives include development of a new system of television with a higher frequency, development of a system of sound and picture projection by one transmitter (on one carrier wave), development of color television, increasing the range of television transmitters, development of a system of interurban television networks (by wireless or by cable), practical solution of the problem of a large screen, facilitating demonstration of television broadcasts to



This graph shows frequency ranges covered by each unit. Write us for your full-size copy.



Five Standard Slug-Tuned LS3 Coils Cover ½ to 184 mc

For strip amplifier work, the compact (1¼" high when mounted) LS3 Coil is ideal. Also for Filters, Oscillators, Wave-Traps or any purpose where an adjustable inductance is desired.

Five Standard Windings—1, 5, 10, 30 and 60 megacycle coils cover inductance ranges between 750 and 0.065 microhenries.

CTC LS3 Coils are easy to assemble, one ¼" hole is all you need. Each unit is durably varnished and supplied with required mounting hardware.

SPECIAL COILS

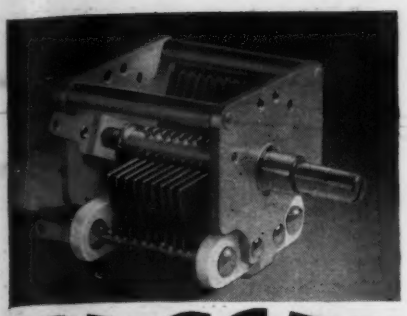
CTC will custom-engineer and produce coils of almost any size and style of winding...to the most particular manufacturer's specifications.

Consult CTC for Three-Way Component Service

Custom Engineering . . . Standardized Designs . . .
Guaranteed Materials and Workmanship

CAMBRIDGE THERMIONIC CORPORATION

437 Concord Avenue, Cambridge 38, Mass.



RUGGED "RMC" CAPACITOR

The RMC, Rugged Midget Capacitor, is designed for use where strength and solid construction are as important as sound electrical design.

Its sturdy frame consists of 3/32" aluminum end plates reinforced by three horizontal pillars which hold the assembly absolutely rigid.

The RMC is ideal for use in mobile equipment where the capacitor frame itself can be used to support other components.

WRITE FOR FOLDER

HAMMARLUND

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MANUFACTURERS OF PRECISION COMMUNICATIONS EQUIPMENT

PRECISION POTENTIOMETERS

Potentiometer Toroidal Type

For use in electrical computers, servo systems and other control circuits where 360° rotation, high precision and low noise levels are essential.

Can be supplied in a wide variety of styles within linear resistance ranges from 500 to 20,000 ohms—Linearity ±.3%; enclosed toroidal wound, low torque, electrical angle 360° or less. Capable of rotation through angles greater than 360°.

SPECIAL FEATURES: Capability of continuous rotation—Accuracy of linearity—Wide variety of contact and tapping arrangements—Durability, the RL-210 type (6000 ohms, 2 brushes) showed no serious wear nor measurable departure from initial characteristics following over one million revolutions at speed of 20 RPM—Overall diameter 3 15/16", height 2 15/16".

Write for Bulletin F-68

THE GAMEWELL COMPANY

NEWTON UPPER FALLS 64, MASSACHUSETTS

Crystals for the Critical

"STABILIZED"

H11 FOR MARINE AND AIRPLANE APPLICATION

The H11 is known the world over as the old standby for airplane and marine application. Frequency tolerance held to .004% over a wide temperature range. 3-pin base with pin diameter .156" and spaced .500 and .812". Can be supplied with two crystals or one crystal and a heater unit for maintaining constant temperature.

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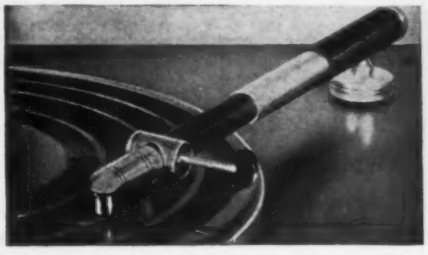

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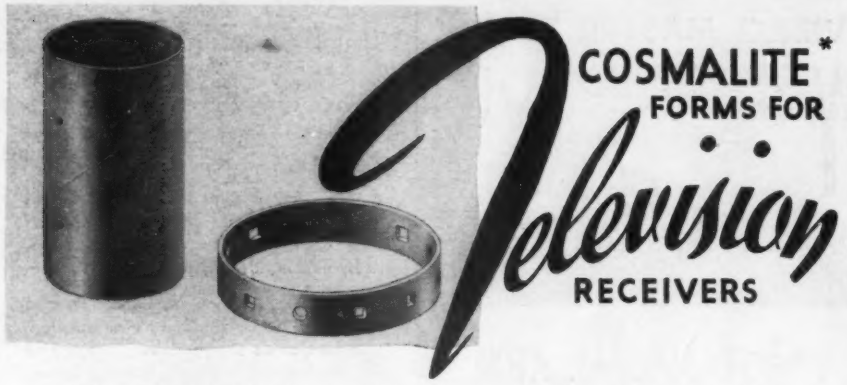

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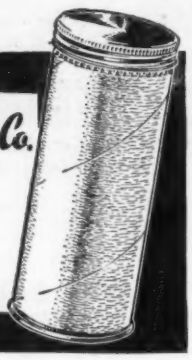

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BUSINESS NEWS

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U. S. INSTRUMENTS CORP., formerly of East Orange, N. J., moved their executive offices and plant to 409 Broad St., Summit, N. J.

INDUCTION HEATING CORP. has moved to its recently completed

New Induction Heating Corp. plant

quarters at 181 Wythe Ave., Brooklyn 11, N. Y.

SPERRY GYROSCOPE CO., INC., Great Neck, N. Y., announces shipment of 45 loran receivers since June 1945.

ZENITH RADIO CORP., Chicago, Ill., recently bought a new two-story building at 912-22 Washington Blvd., Chicago.

THE ERWOOD CO. has moved to 214 Woodstock St., Crystal Lake, Ill. The new plant provides complete facilities for electronic consulting, development, research, and engineering.

DOONE AND MARGOLIN, ANTENNA CONSULTANTS, Freeport, N. Y., is a recently established firm. The founders were formerly with Airborne Instruments Laboratory, Mineola, N. Y.

SPERTI, INC., Cincinnati, Ohio, manufacturer of ultraviolet equipment, has purchased the Faraday Electric Corp., Adrian, Michigan.

THE *RGH* MFG. CORP. has moved to a larger plant at 365 Canal St., New York 13, N. Y.

ALTEC LANSING CORP., Hollywood, purchased the Peerless Electric Products Co., of Hollywood, thus increasing its West Coast manufac-

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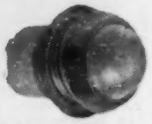

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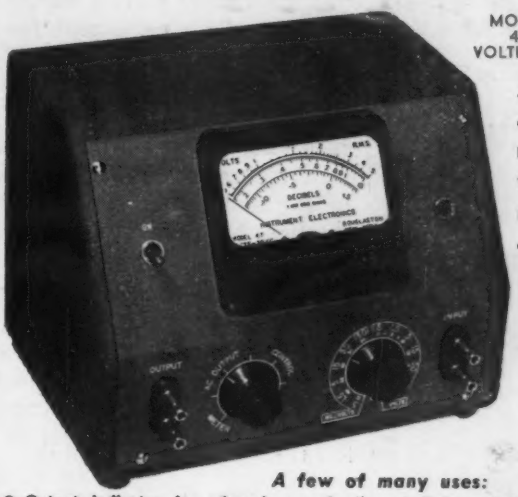

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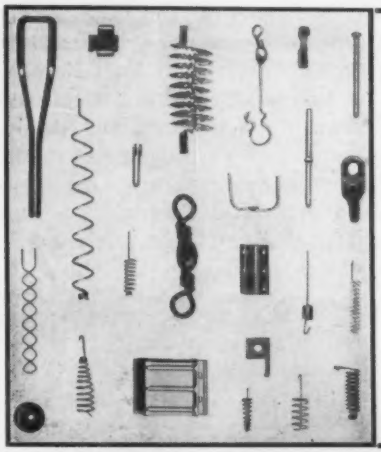

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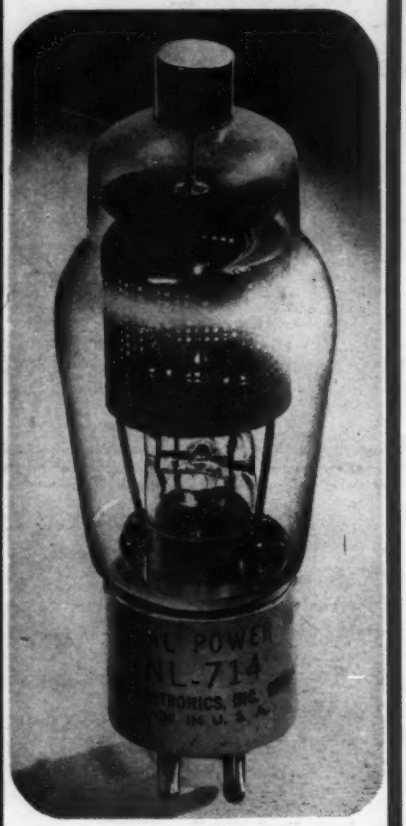

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INDUSTRIAL SYNTHETICS CORP., manufacturers of flexible plastic tubing and tape for electrical insulation, have moved from Irvington, N. J. to their new plant at 225 North Ave., Garwood, N. J.

NICOLAS ANTON, formerly vice-president in charge of manufacturing, is now president of Amperex Electronic Corp., Brooklyn, N. Y.

MICHAEL HALSALL is chief engineer of Arlington Electrical Products, Inc., New York City, organized recently for manufacture of audio equipment.

THOMAS E. STEWART, JR., has been named chief of the Applied Electronics Branch of the U. S. Army Engineer Research and Development Laboratories at Fort Belvoir, Va. He received the Exceptional Civilian Service Award for his development of metallic, nonmetallic, and underwater mine detectors, a radio explosives detonator, and a barrage balloon flight analyzer.

T. E. Stewart, Jr.

P. S. Fogg

PHILIP S. FOGG, president of Consolidated Engineering Corp., Pasadena, Cal., has been appointed special advisor to the acting manager of the Chicago Directed Operation, Atomic Energy Commission.

ROBERT G. HERZOG is now vice-president in charge of engineering at Universal General Corp., New York

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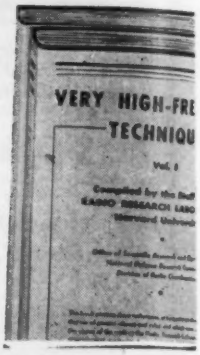

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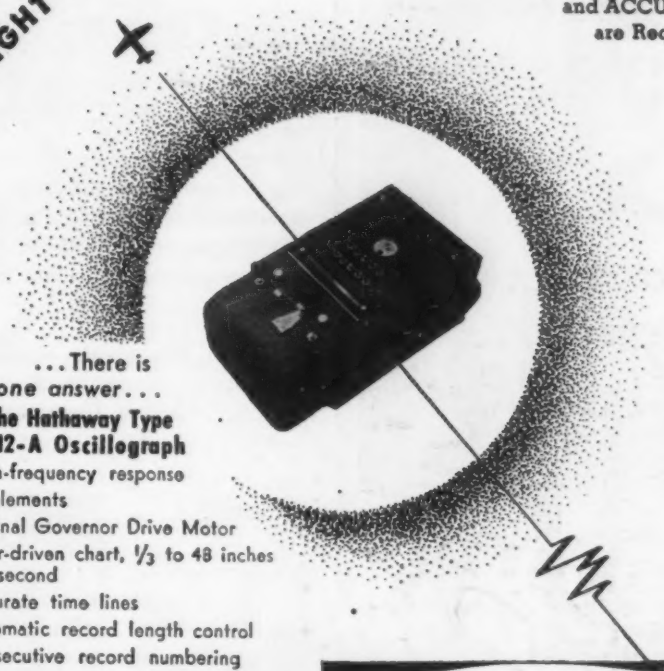

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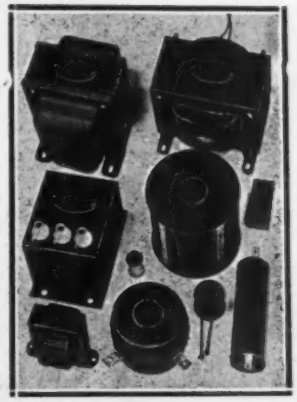

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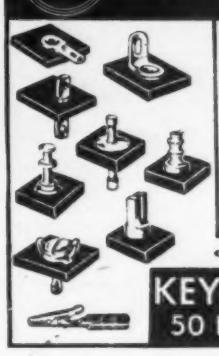

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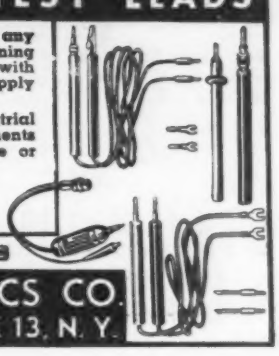

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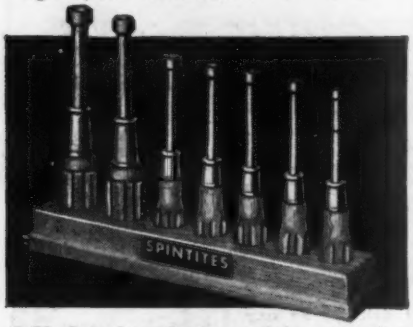

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HARVEY C. RENTSCHLER, after a 30-year career directing Westinghouse lamp and electronic tube research at Bloomfield, N. J., has retired.

ALFRED N. GOLDSMITH, editor of *Proceedings of the IRE* and former vice-president of RCA, is now an associate with Richard W. Hubbell and Associates, television consultant firm.

EDWARD A. MILLER was elected vice-president in charge of engineering at Acme Electric Corp. of Cuba, New York.

E. A. Miller

S. J. Deitz

STEPHEN J. DEITZ, formerly in charge of design engineering with the Ripley Co., is now head of sales engineering at The Langevin Manufacturing Corp., New York City.

A. C. KRUEGER has joined the staff of Airborne Instruments Laboratory, Mineola, N. Y. as supervising engineer for the antenna design section. He served as development engineer on a guided missiles project at Republic Aviation Corp. since February 1946. From 1943 to 1945 he worked on the Manhattan Project at the University of Chicago.

LAURISTON S. TAYLOR, chief of the x-ray section at the National Bureau of Standards, was elected associate fellow in the American College of Radiology.

DAVID SARNOFF is now chairman of the board of directors as well as president of RCA, following retirement of General J. G. Harbord, who has served as chairman since 1930.

ORRIN E. DUNLAP, JR. has been elected vice-president in charge of advertising and publicity at Radio

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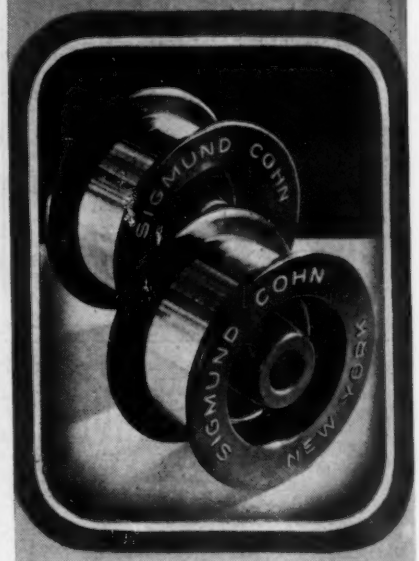

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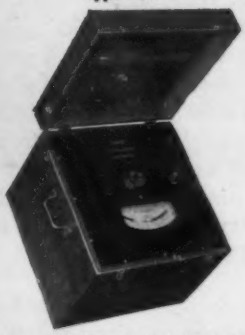

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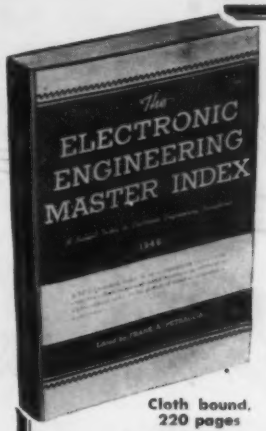

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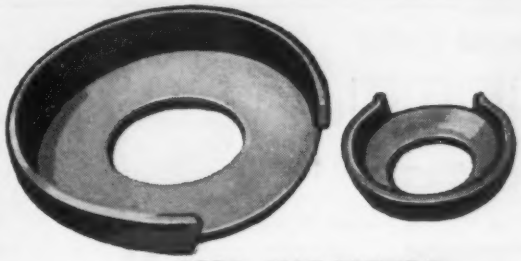

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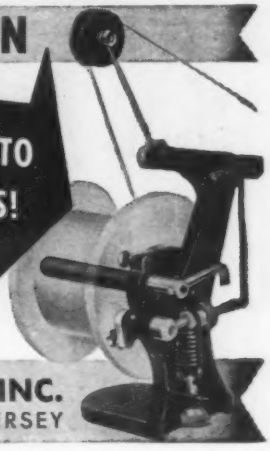

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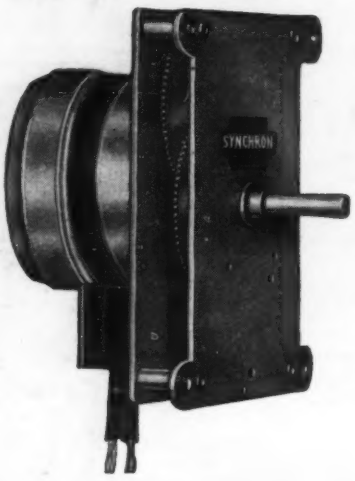

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Corporation of America. For 18 years prior to joining RCA in 1940 he was radio editor of the New York Times.

HARRY J. WOLL, adavanced development engineer at RCA's Camden plant, is the first RCA Victor employe to receive an RCA fellowship under a new plan for encouraging the company's engineers to obtain advanced degrees. He will work toward his doctor's degree at the University of Pennsylvania in the 1947-1948 academic year.

HOWARD C. SCHUBERT, with Allen B. DuMont Laboratories for five years as research engineer, has been appointed a senior engineer at U. S. Television Mfg. Corp.

EVERETT B. BOISE, recently with National Union as chief commercial engineer, was appointed sales engineer for Hytron Radio & Electronics Corp.

T. KEITH GLENNAN, holder of the Medal for Merit as wartime director of the U. S. Navy Underwater Sound Laboratory, has been selected as new president of Case Institute of Technology, Cleveland, Ohio.

T. K. Glennan

A. Wright

ANTONY WRIGHT, with RCA for nineteen years and former manager of their television receiver engineering section, was recently appointed chief engineer of U. S. Television Mfg. Corp.

SAMUEL C. MILBOURNE, formerly chief engineer of Eastern Amplifier Corp., is now manager of engineering consulting and buying service for K. Streuber & LaChicotte, New York City.

JACK DE WITT, formerly chief engineer, has returned to station WSM, Nashville, Tenn., as president of the station.

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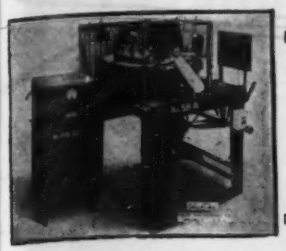

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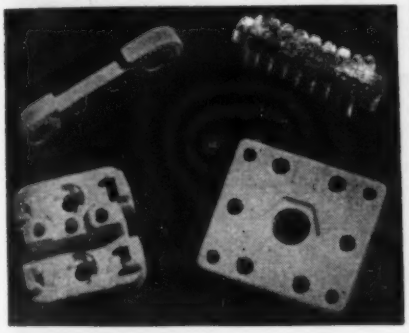

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Modulus of Rupture	20,000 lbs. per square inch
Dielectric Strength	235 volts per mil
Dielectric Constant	6.42 Frequency of
Loss Factor	.7.90 1 megacycle
Power Factor	.4.46
Bulk Specific Gravity	2.864%
Density (from above gravity)	0.098 lbs. per cubic inch
Hardness (Mohr scale)	7.0
Softening Temperature	2,350° F.
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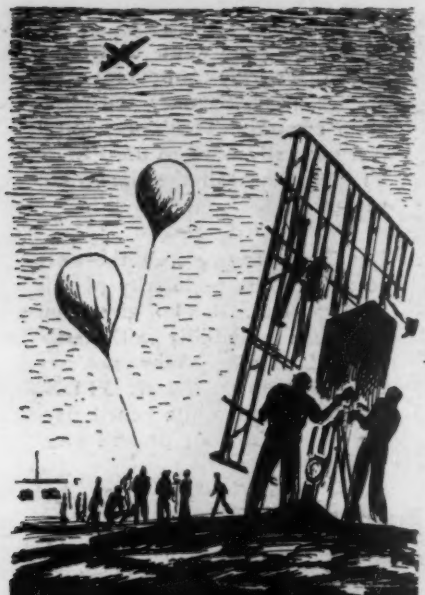

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NEW BOOKS

Television Techniques

BY HOYLAND BETTINGER. *Harper & Brothers, New York, N. Y., 1947, 237 pages, $5.00.*

THIS IS the second book stemming from the production experience at WRGB in Schenectady. The author, an artist, has made notable contributions to the art by emphasizing and analyzing its visual aspects. This study, introduced with a well-illustrated explanation of how television works, actually begins with an analysis of the medium. Although basically sound, certain generalizations regarding television's limitations are no longer true, due to technical advancements. For example, space limitations can possibly be overcome by employing the Zoomar lens and multiple cameras.

Pictorial composition and continuity, visual and audio techniques, television script writing, producing, and directing are covered in the text. Unfortunately mediocre material on play direction is included. Too sketchy, and often faulty, it is apt to mislead the uninitiated. The student of play directing can find better and fuller material elsewhere.

Occasionally the author completely misses his mark. Figure 17 on page 41 attempts to illustrate rhythmic spacing. Actually it is an example of emphasis gained by the use of (1) body position, (2) actual line, (3) area, (4) space, (5) visual line, and (6) focus, which constitute quite a battery of play-directing techniques. Illustrations for beginners are best when demonstrating only the point under discussion. The last two chapters, Motion Pictures and Film Integration and Television Lighting, are excellent little primers on their subjects.

The techniques here described imply a full quota of studio personnel, as is currently used in large studios. Since most television stations in the near future probably will require considerable doubling on the part of their staffs, suggestions along these lines would have been valuable. Even more disappointing is the lack of any discussion of program types. Vision and imagination regarding the shape of

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programs to come would be welcome.

Mr. Bettinger's analytical work of an art still in the embryo stage deserves close study. Studio and technical personnel could profit by a line-by-line reading.

—VIRGINIA M. BRADLEY

Elements of Electrical Engineering

BY A. L. COOK AND C. C. CARR. *John Wiley & Sons, Inc., New York, N. Y., Fifth Edition, 662 pages, $5.00.*

A HIGHLY successful textbook, presenting a background of electrical engineering for students specializing in other fields, is here brought up to date. Four excellent chapters on electronics now include industrial applications as well as fundamentals. Circuit diagrams commendably use reasonable approximations to ASA symbols. —J. M.

Technical Dictionary

BY HANS THALI, *Hitzkirch, Switzerland. Distributed by W. S. Heinman & Co., 125 E. 23 St., New York, N. Y., 1946, 275 pages, $6.25.*

AN ENGLISH-GERMAN-FRENCH dictionary (English terms in alphabetical order, each followed by its German and French equivalents) covering terminology of electrical engineering, radio, television, electrical communication, and most-used terms of acoustics, illumination, mathematics, optics, and other related fields. Coverage of English radio and electronic terms is commendably complete and should be adequate for most users.—J.M.

Men and Volts at War

BY JOHN A. MILLER. *Whittlesey House, McGraw-Hill Book Co., Inc., New York, N. Y., 1947, 272 pages, $3.75.*

ALTHOUGH only two of the twenty chapters deal with electronic equipment exclusively in this story of how General Electric Co. mobilized for production in World War II, this entire book makes fascinating reading for those who perchance have missed similar works such as "Scientists Against Time." Radar production was one of the com-

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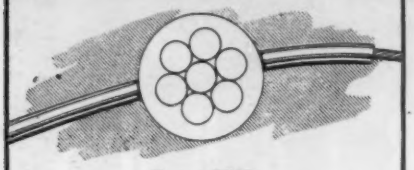

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Highways in the Sky

BY LOUIS SHORES. *Barnes & Noble, Inc., New York, N. Y., 1947, 269 pages, $3.00.*

THIS IS the story of the Army Airways Communications System that, by V-J day, was operating a thousand airways stations in every part of the world and creating highways in all the skies over this world so that man might fly safely wherever he chose. The book is filled with dramatic anecdotes of radio operators working right through strafing and bombing attacks on airport control towers to keep homing beacons in operation, bring planes down safely, and send and receive vital messages. Every radio man will enjoy the adventures set down in print here for the first time as the AACS history.—J.M.

The Strange Story of the Quantum

BY BANESH HOFFMAN, *Department of Mathematics, Queens College, New York, Harper & Brothers, New York 1947, 239 pages, $3.00.*

QUANTUM mechanics, whereby scientists have analyzed and accounted for the behavior of nuclear particles and radiations, has become interesting to laymen as the underlying explanation of atomic energy. The author has readably presented, in historical sequence, the development of the concept of the quantum, restricting himself to purely descriptive text for the benefit of the nonmathematically inclined (such as salesmen and executives) who have to know, but need not apply, modern scientific concepts. —F.R.

THE EDITORS are informed by Carl E. Smith, author of the book "Directional Antennas," reviewed in the June 1947 issue, that the book contains 15,160 antenna patterns, rather than the 238 polar charts mentioned in the review.

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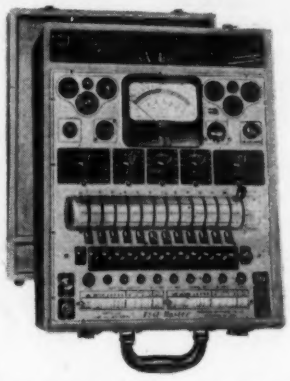

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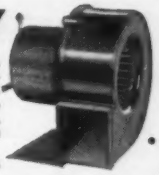

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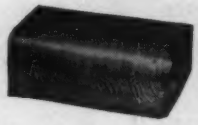

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Common Sync Signal

DEAR SIRS:

IN A situation where many video channels would be occupied in a locality, as in a large metropolitan area, it would be of advantage to have a common stable line sweep frequency generator for all the cameras of all the stations in the area. This standard, of course, would be a sinusoidal generator to control the rate of the various local sweep oscillators.

Of several methods . . . most convenient would be a small, low-frequency transmitter, operating in a clear channel, modulated by the sweep frequency tone, or a submultiple of it for bandwidth conservation. The maintenance of the transmitter should be assigned to one of the video stations.

All the video receivers in the area could have relatively high-Q flywheel tanks in their horizontal sync circuits, tuned to the stable common oscillator sweep frequency. These tanks would be shock-excited by the sync pulses, in turn to control the rate of the local blocking oscillators or multivibrators. This stable sweep rate would be utilized by all the video stations in the area, so that there would be no need for a front-panel sync control. Where the power line frequencies were different among the various stations, a common vertical sync rate could also be transmitted.

Variations of the system could include the transmission of the rates by a central station, as WWV.

The only complication in the actual video broadcast would be a low-frequency receiver at the camera site for reception of the sweep and frame-rate control signals from the central transmitter. This receiver should incorporate a very narrow audio bandpass filter about the sweep frequency to make it rela-

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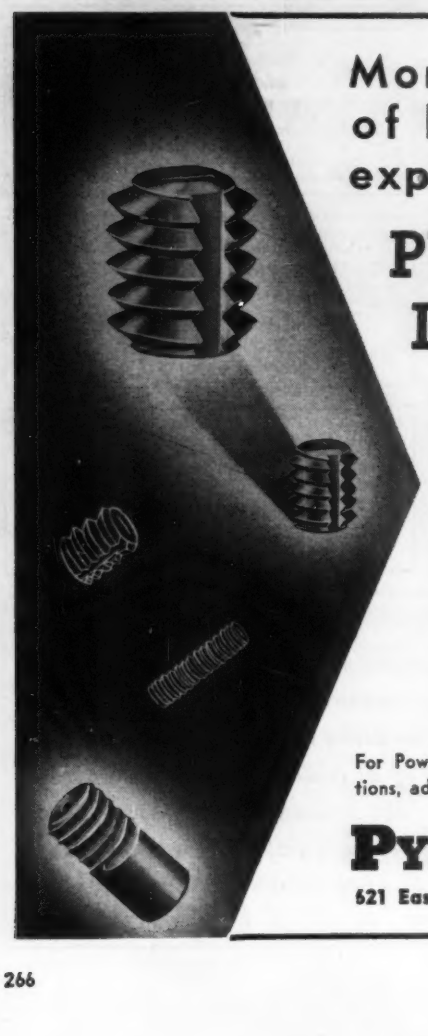

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tively insensitive to interference commonly present at the lower frequencies.

LEO MACKTA
Brooklyn, N. Y.

F-M Set Standards?

Dear Sir:

I HAVE just read the July 1947 article "New Approach to FM-AM Receiver Design". The f-m design is radical in that it omits, among other things, the limiter stage. It would seem that this would be an ideal situation for a limiter to overcome other deficiencies since the r-f gain is not uniform over the band. I have not heard this set perform and am willing to be convinced.

I have serviced a popular brand f-m set with no r-f stage. I am afraid I can forsee a few years to peeps, burps, squeeks, howls, and whistles on the f-m band that we now have on the a-m band.

I would like to see an expression from the industry in general with regard to a set of standards, for f-m set manufacturers, to preserve the advantages of f-m.

RICHARD C. BOWERS
Emeryville, California

Electronism

Dear Sir:

I HAVE read with interest the article in the June issue, "Nucleonics and Electronics". The use of this new term nucleonics brings to mind a word which I first used in 1944 when working at Columbia University on the Manhattan Project.

The word to which I refer is "electronism", with the accent on the second syllable, thus e-lec'tronism. This word bears the same relation to "electronics" as does "mechanism" to "mechanics". The accent shifts by one syllable in both cases. I do not find the new word awkward to use, once the accent has been placed correctly.

Electronism eliminates the need for the term "electronic device", or worse, "electronic gadget". In its relation to mechanism it immediately connotes either a component of equipment or the entirety of equipment.

JAMES N. SMITH
Chief Engineer
Moisture Register Co.
Laguna Beach, California

electronics

A McGRAW-HILL PUBLICATION

NOVEMBER • 1947

CONSOLE FOR DUBBING ..... Cover
Control console for mixing up to nine sound channels to make the final sound-on-film track at Reeves Sound Laboratories, New York (see p 142)

ELECTRONICS SPONSORS CITIZENS RADIO PROJECT 80
Announcing a program designed to test the potentialities of the 460 to 470-mc band

TRANSMITTER FOR THE CITIZENS RADIO SERVICE, by Walter C. Hollis 84
Simple low-power f-m unit meets FCC Class-A specifications for 460 to 470-mc band

MEASURING PRESSURES OF INDUSTRIAL EXPLOSIONS, by N. T. Thompson and E. W. Cousins 90
Pressure-time diagram is photographed on c-r screen, using capacitance pickup with 10,000-cps bridge

F-M CHAIN BROADCASTING 94
Prewar program distribution techniques are rediscovered as a means of making money for f-m broadcasters

TEMPERATURE CONTROL FOR OCTANE TESTS, by Pierre J. Malraison 99
Circuit operates up to 250 times per minute to maintain constant gas-air temperature for test engine

INTERCONNECTING FACILITIES FOR TELEVISION BROADCASTNG, by W. E. Bloecker 102
Television facilities will provide local pickup circuits and nationwide networks

ELECTRONIC COMPUTER FOR PRINTING CONTROL, by John Ludwig 108
Electronic-hydraulic control system triples speed of a multicolor printing press

RECORDING SKY-WAVE SIGNALS FROM BROADCAST STATIONS, by W. B. Smith 112
Cycler circuit blacks in area under curve on strip chart for quick analysis by electronic scanner

ELECTROMECHANICAL D-C AMPLIFIER, by C. G Roper and J. F. Engelberger 117
Combining a vacuum-tube oscillator and a mechanical system provides a high-gain stable d-c amplifier

SIMPLIFIED MICROWAVE AFC—Part I, by F. A. Jenks 120
Motor and electronic circuits combine to give 200-kc control of 3,000-mc carrier for unattended relay station

RECORDER AND TIMER FOR SHORT INTERVALS, by Warren Bliss 126
Interval-defining pulses gate 4-mc oscillator to drive counter indicating up to 16 μsec in 0.25 μsec steps

PRODUCING TUBE CURVES ON AN OSCILLOSCOPE, by Henry E. Webking 128
Circuit automatically changes grid voltage after each trace to produce family of curves

VOLTMETER LOADING, by R. E. Lafferty 132
Nomograph gives true voltage in high-impedance circuit after two readings with ordinary low-sensitivity voltmeter

DESIGN OF MERCURY DELAY LINES, by T. K. Sharpless 134
Ultrasonic delay lines can store information indefinitely by a recirculation technique

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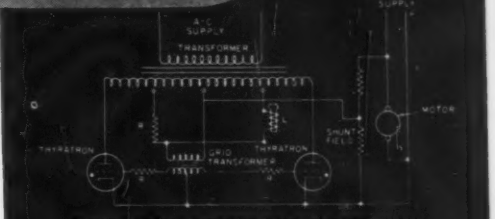
CHARACTERISTICS

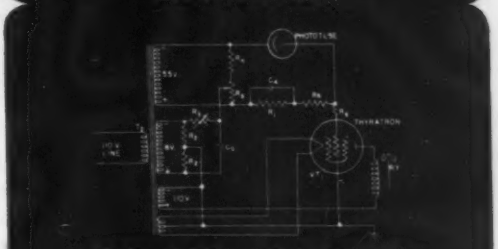
	GL-502-A	GL-546
Max over-all height	2 19/32 inches	1½ inches
Max over-all diameter	1 5/16 inches	¾ inch
No. of electrodes	4	4
Cathode voltage	6.3 v	6.3 v
current, approx	0.6 amp	0.15 amp
heating time, typical	10 seconds	10 seconds
Peak voltage drop, typical	11 v	11 v
Average anode to control-grid capacitance	0.2 mmfd	0.1 mmfd
Ambient temperature limits	−55 to +90 C	−55 to +90 C

MAXIMUM RATINGS

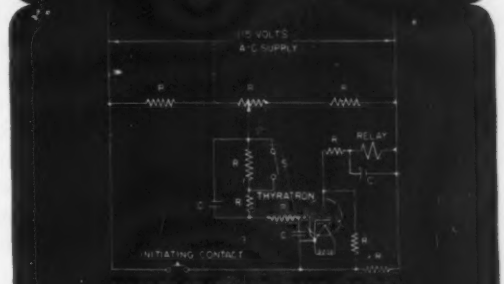
Peak anode voltage, inverse	1,300 v	500 v
forward	650 v	500 v
Anode current, instantaneous	1 amp	100 ma
average	100 ma	20 ma
Time of averaging anode current	30 seconds	15 seconds



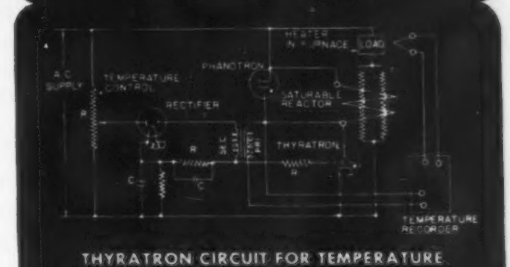
THYRATRON CIRCUIT FOR CONTROL OF SMALL D-C MOTORS



PHOTOTUBE DOUBLE-GRID THYRATRON RELAY CONTROL CIRCUIT



THYRATRON TUBE TIMER CIRCUIT



THYRATRON CIRCUIT FOR TEMPERATURE CONTROL USING A SATURABLE REACTOR

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The Solar System
electronics edition · November 1947

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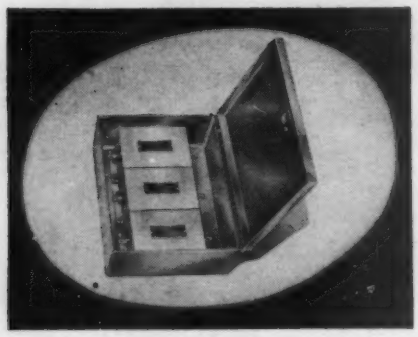

Solar Type EB series Elim-O-Stat radio interference filters are intended for heavy-duty service in 1, 2 and 3 phase circuits and equipment drawing from 5 to 200 amperes, 250V a-c/600V d-c. Voltage drop is negligible.

Type EB filter assemblies have a noise elimination range of from 150 Kc to 250 Mc covering all frequencies used for radio communication and entertainment, as well as commercial television. Most efficient in eliminating line-conducted radio interference when connected immediately adjacent to motors, generators, electric elevators, diathermy machines, X-ray apparatus, electronic heating equipment and other devices generating radio noise, they are also highly effective when connected at the power service entrance to remove noise entering via electric power distribution circuits.

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SOLAR
Elim-O-Stat
Radio Interference Filters

BUSINESS BRIEFS

By W. W. MacDONALD

"Electronics will dominate the next 50 years in astronomy as much as photography dominated in the past 50 years," says Otto Struve of Chicago University's Yerkes Observatory.

We Understand that IRE has already sold all exhibit space on the first floor of New York's Grand Central Palace, where the March show will be held. Space is still available on the balcony.

Superregeneration has been taken down from the commercial shelf, dusted off and once more put to work, notably in certain inexpensive f-m tuners. Not too much is known about the theory of superregenerative circuits but some studies were made during the war. ELECTRONICS is at present endeavoring to pry data loose for early publication.

Hearing Aids in use in the United States total between 500,000 and 600,000. About 125,000. were sold in 1946 and at this writing it looks like sales will reach 200,000 in 1947.

We hesitate to estimate the size of the potential market owing to wide differences of opinion in the industry regarding the number of hard-of-hearing and how many of these can be helped by hearing aids. It appears likely, however, that the popularity of single-unit models will result in a substantial increase in business during 1948.

Licenses covering some 700 patents in the radio receiver, electrical phonograph, and television receiver fields have been offered all set manufacturers by Philco.

Commercial Radar installations aboard American vessels were estimated earlier this year (p 82, April) as totalling 85. We have no later figures covering the output of the entire industry but the picture is obviously changing rapidly. RCA reports the installation of 81 equipments operating on 3.2 cm since January. Some 40 of these are aboard American ships.

Machine Tool Show exhibits featured more electronic accessories than in previous years. Motor control devices employing tubes were everywhere in evidence. Electronically controlled chucking grinders and sizing mechanisms were shown. Conversations with people attending the show also disclosed that machine manufacturers were perfecting electronically controlled hosiery knitting machines, blind gaging devices and other devices soon to be described elsewhere in ELECTRONICS.

Teaneck, N. J. Dogcatcher receives tipoffs concerning stray canines in his car from the local police radio station.

Commercial Broadcast Picture for the continental United States, as of August 1, 1947, is as follows:

Licensed A-M Stations	1,266
A-M Construction Permits	500
Licensed F-M Stations	52
F-M Construction Permits	639
F-M Conditional Grants	247
Licensed Television Stations	6
Television Construction Permits	60
TOTAL	2,770

Breakdown of the 1,266 licensed a-m stations listed above:

Clear Channel	
Unlimited (50 kw)	53
Part-time (50 kw)	4
Unlimited (5 to 25 kw)	31
Part-time (5 to 25 kw)	6
Regional Channel	
Unlimited	311
Limited and day	125
Part-time	14
Local Channel	
Unlimited	665
Day and part-time	57

Minimum Cost of equipment required for a modest start in telecasting (500-watt video transmitter and 250-watt audio transmitter) is $89,000, according to DuMont's Herb Taylor.

Underscored by FCC chairman Denny in a speech before the NAB were two statements of particular significance to new applicants for a-m station licenses. Denny said (1) that applicants should be sure they